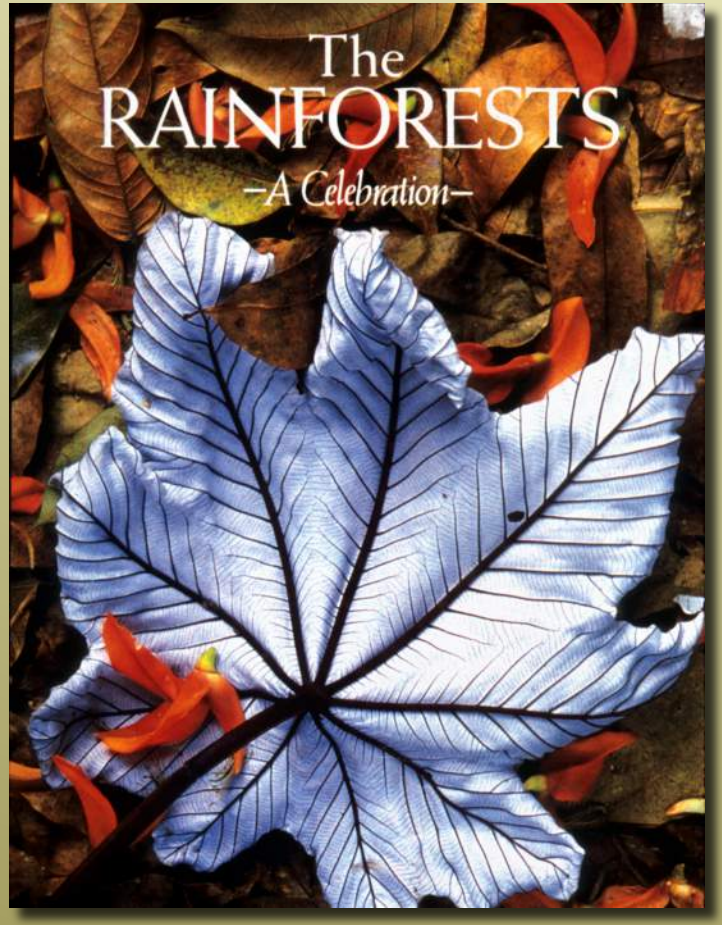
Tropical Rainforest Biome

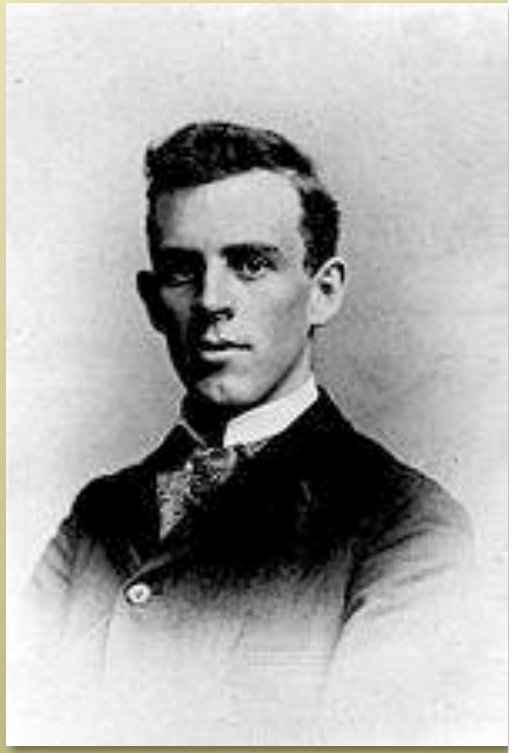
"The land is one great, wild, untidy luxuriant hothouse, made by Nature for herself . . . How great would be the desire in every admirer of Nature to behold, if such were possible, the scenery of another planet! . . . Yet to every person it may truly be said, that the glories of another world are opened to him"



Charles Darwin in *The Voyage of the Beagle*

Tropical Rainforest Biome

"Never to have seen anthing but the temperate zone is to have lived on the fringe of the world"



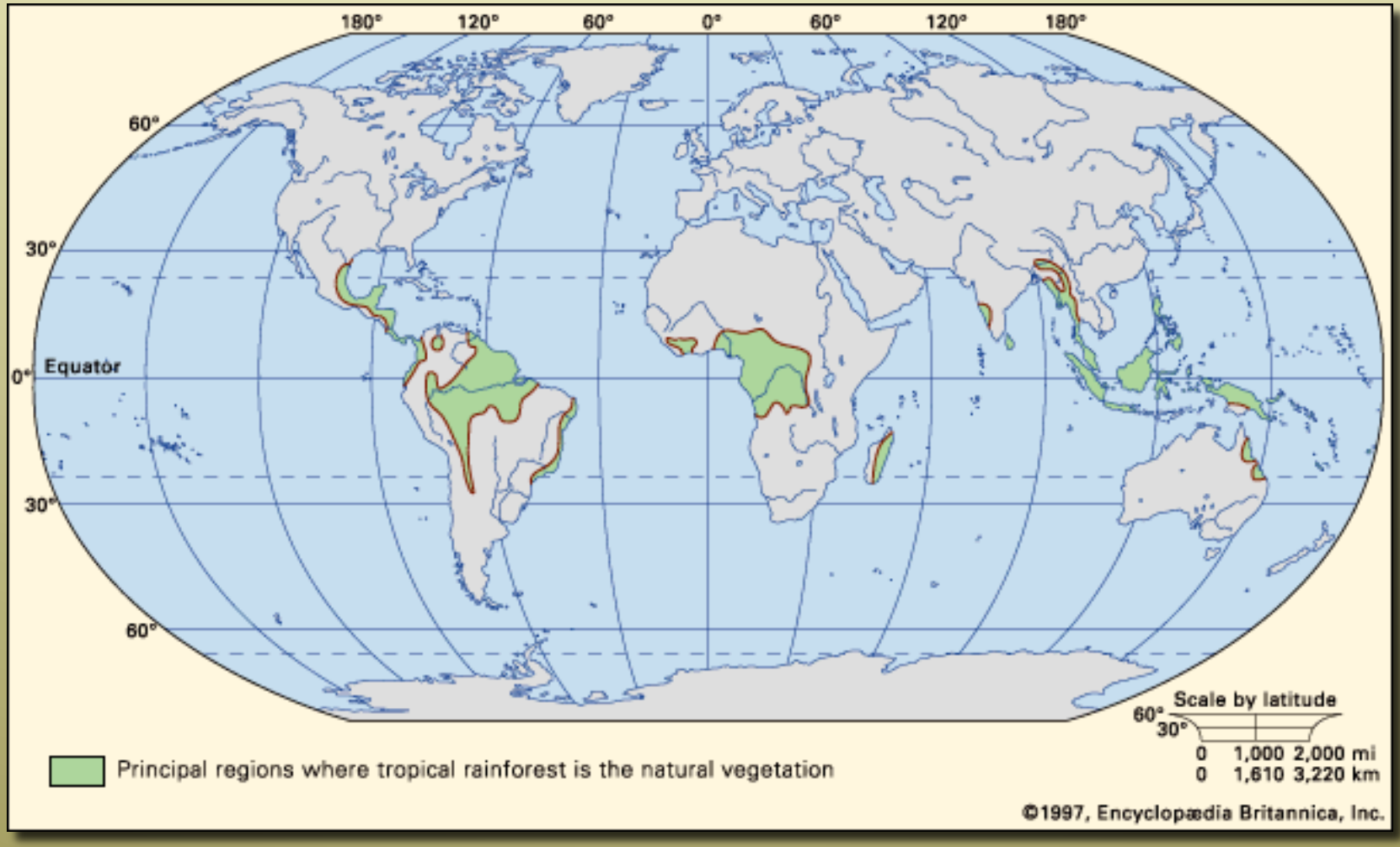
David Fairchild

Tropical Rainforest Biome

- equatorial lowlands and rainbelt; very short dry season
- multi-layered, evergreen canopy, high species diversity
- convergent adaptations around world, but different floras

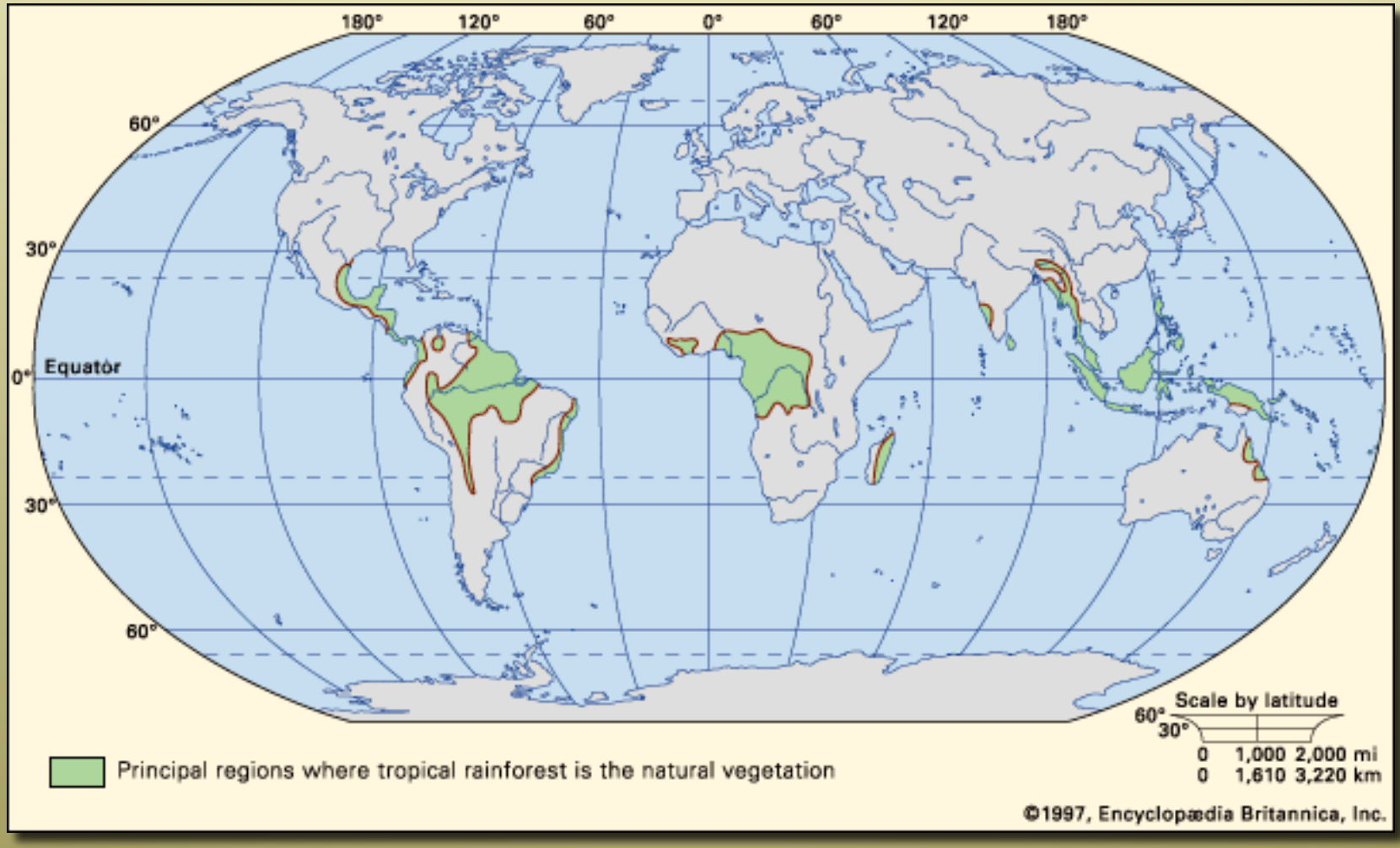
Tropical Rainforest Biome

Location: 1. Equator to 10° or 25° N & S latitude and 0 - 1,000m elevation in Americas, Africa, SE Asia



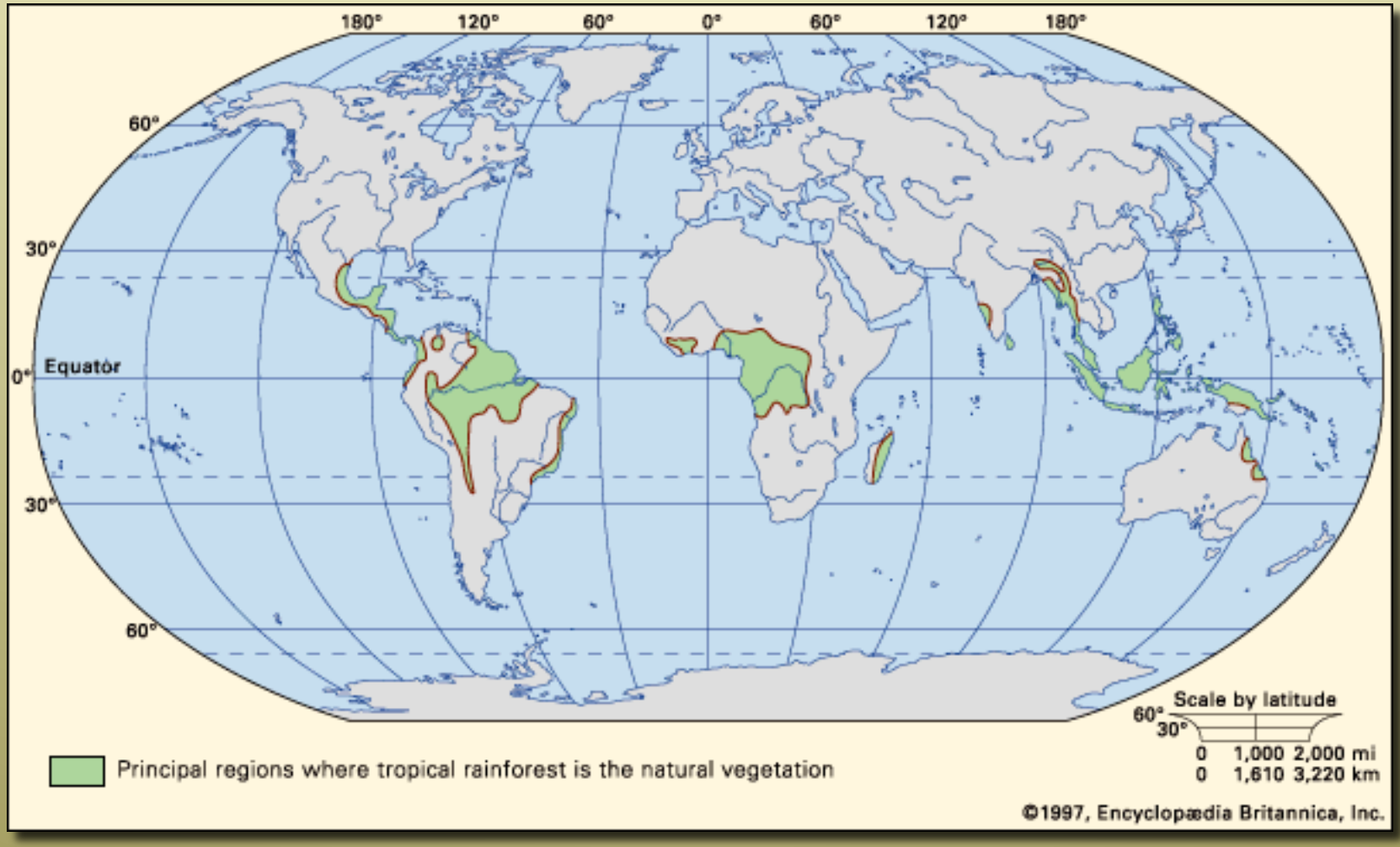
Tropical Rainforest Biome

Location: 2. Along coasts windward to the trades — E. Brazil, Madagascar, NE Australia



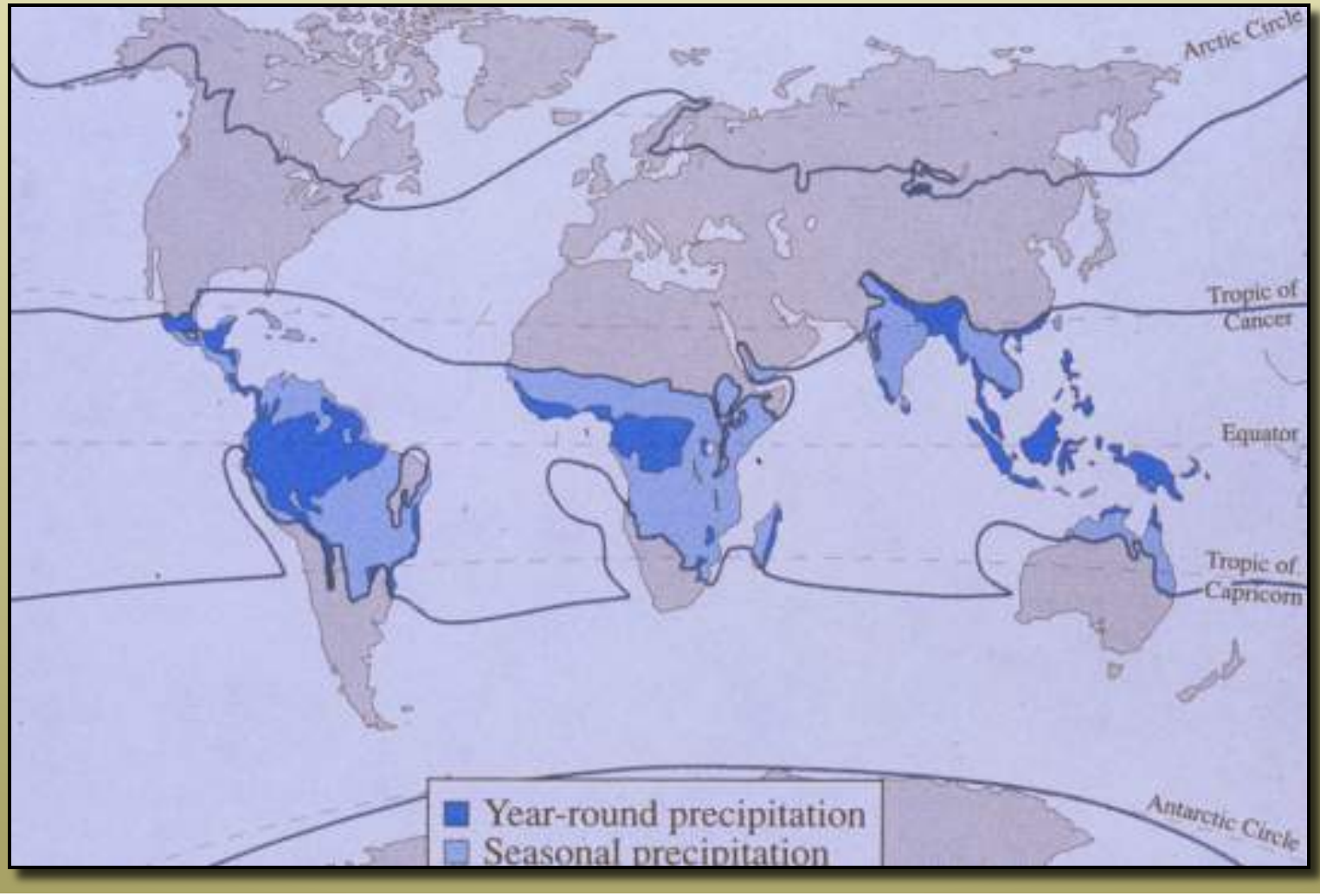
Tropical Rainforest Biome

Location: 3. East coasts with orographic precipitation —
E. Panama and Costa Rica, E. Puerto Rico



Tropical Rainforest Biome

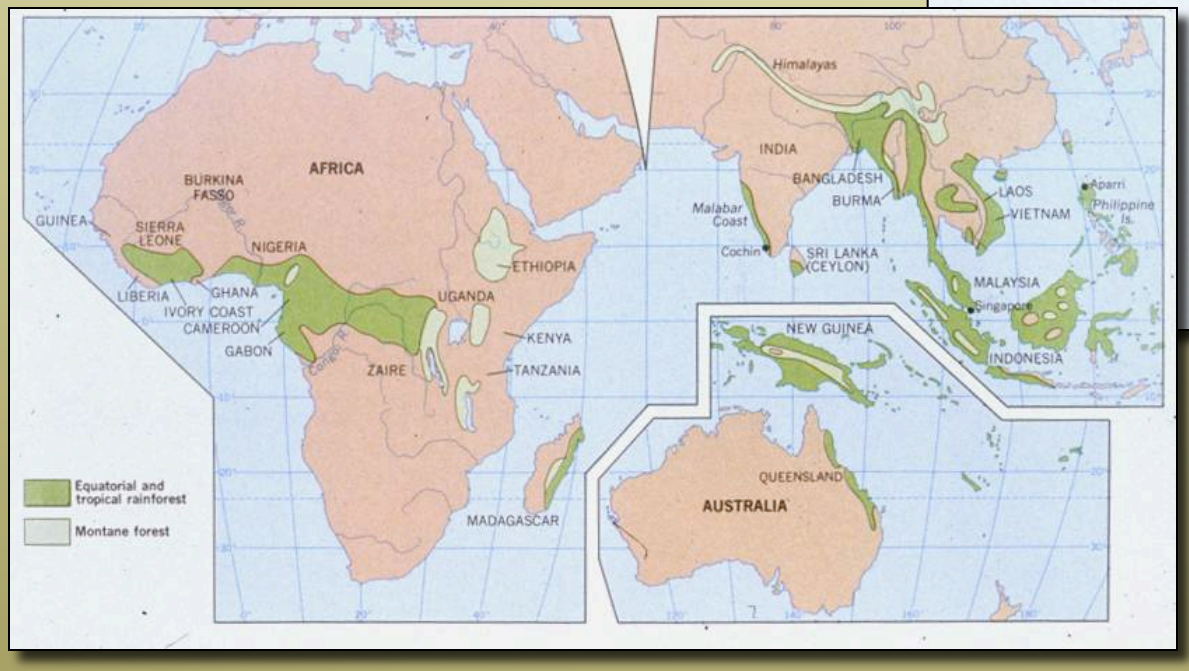
Location: Seasonally dry tropical forests adjacent at higher latitudes or on leeward side of montane regions



Tropical Rainforest Biome

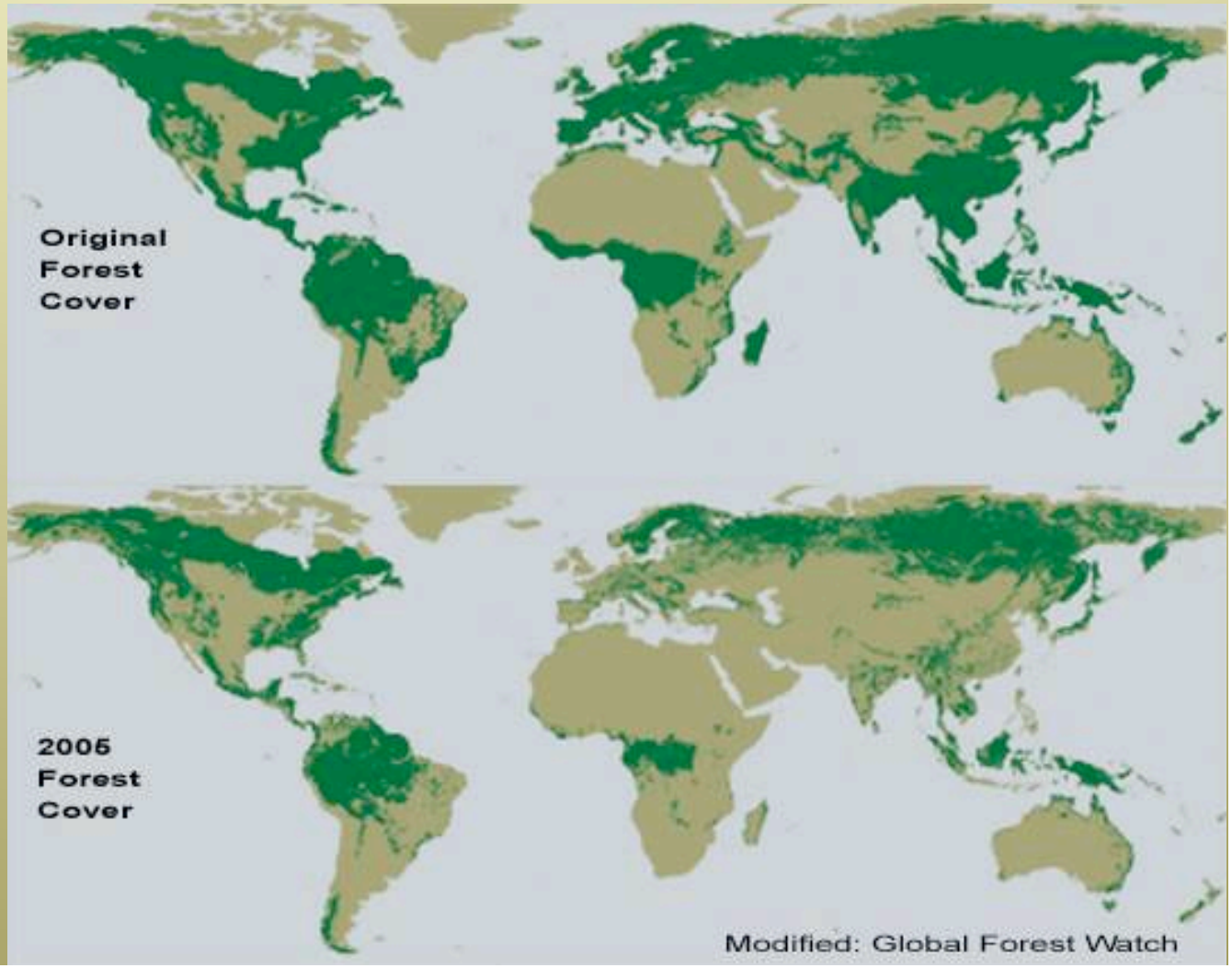
Three floristically diverse regions:

1. American: 50% of area
2. African: 20%
3. S.E. Asian - Pacific: 30%



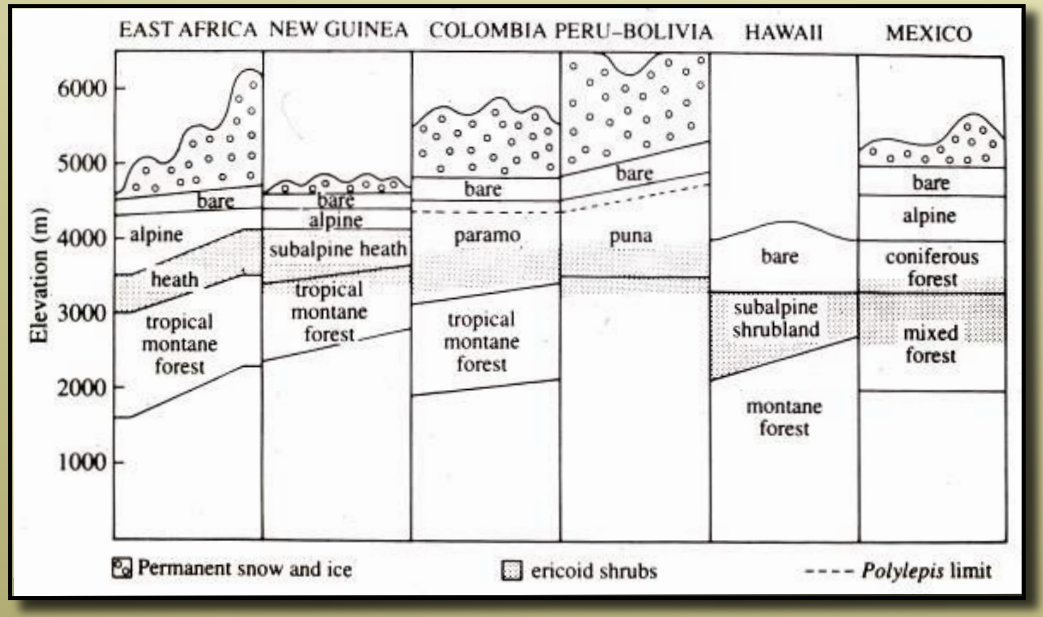
Tropical Rainforest Biome

Fragmentation of rainforests — especially African and Asian — ongoing



Tropical Rainforest Biome

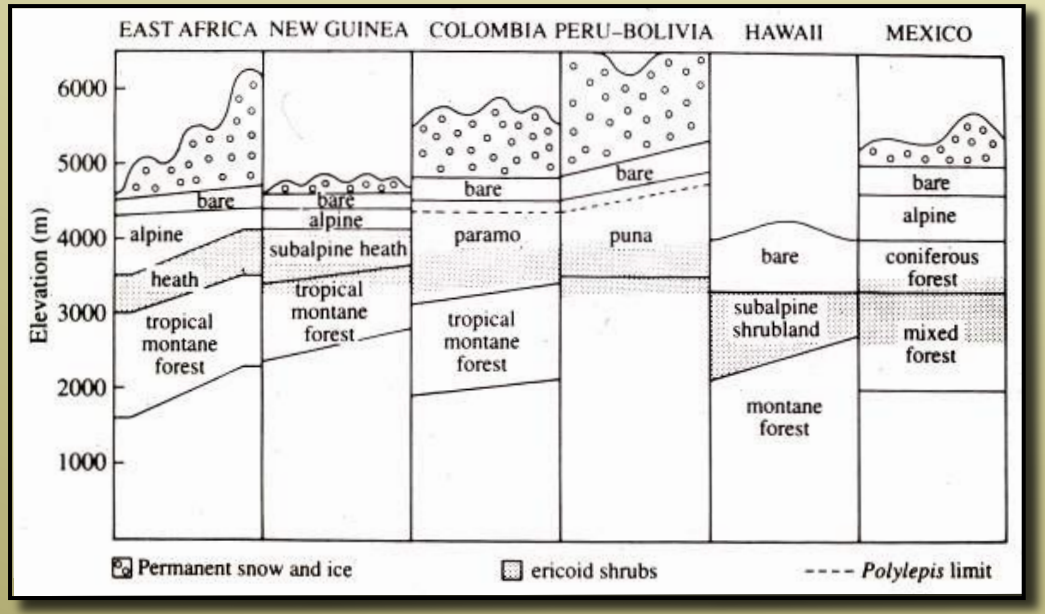
Relationships to other tropical forest systems — elevation gradient:

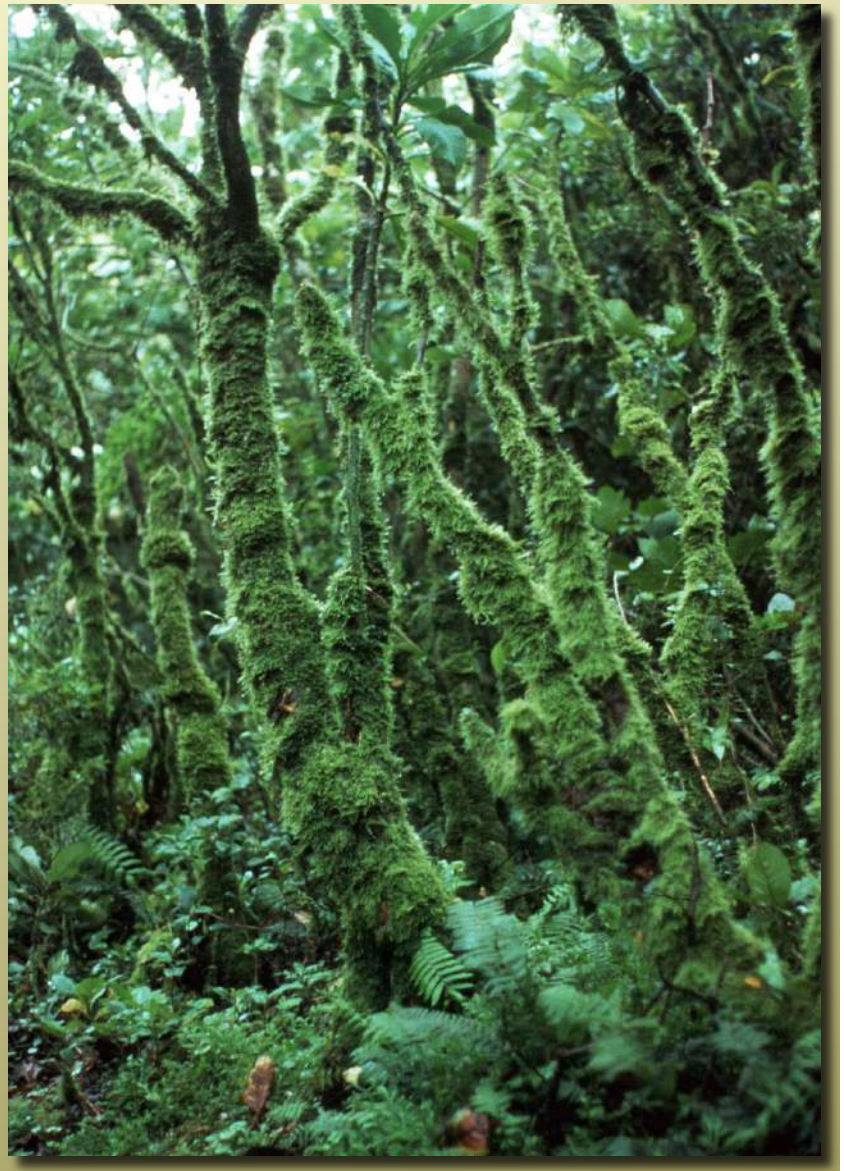


Tropical montane or cloud forest

Tropical Rainforest Biome

Relationships to other tropical forest systems — elevation gradient:

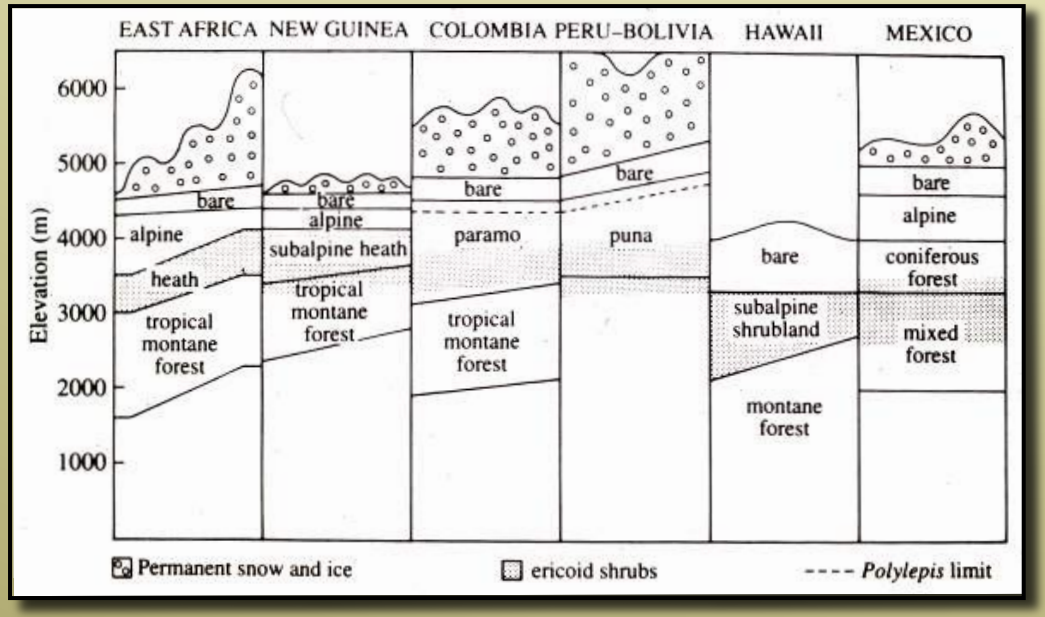




Elfin forest

Tropical Rainforest Biome

Relationships to other tropical forest systems — elevation gradient:



Paramo

Photo: Mauricio Diazgranados

Tropical Rainforest Biome

Relationships to other tropical forest systems — ecological gradient:

Mangrove and beach forests

Tropical Rainforest Biome

Relationships to other tropical forest systems — ecological gradient:

Seasonally flooded swamp forests

Várzea: flooded by muddy water tributaries of Amazon

Rio Beni, Bolivia

Tropical Rainforest Biome

Relationships to other tropical forest systems — ecological gradient:

Seasonally flooded swamp forests

Várzea: flooded by muddy water tributaries of Amazon

flooded vs. dry

Tropical Rainforest Biome

Relationships to other tropical forest systems — ecological gradient:

Seasonally flooded swamp forests

Igapó: flooded by nutrient poor waters of sandy soils (leached tannin stained)

Rio Negro, Amazonas

Tropical Rainforest Biome

Relationships to other tropical forest systems — latitudinal gradient:

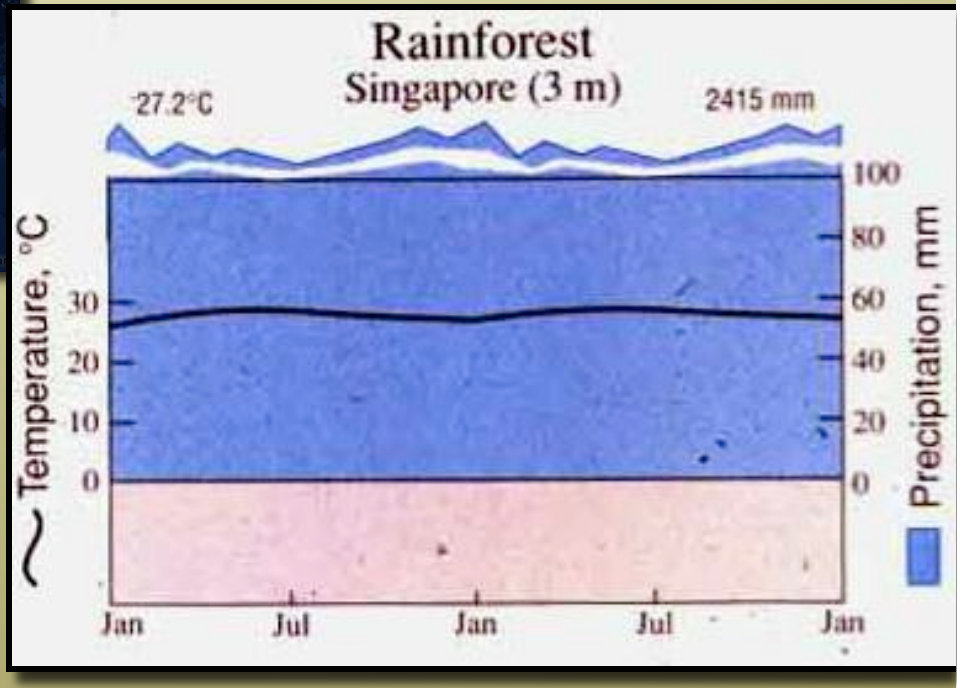
Subtropical deciduous forests (& monsoon, tropical deciduous, thorn forest)

Alamos, Mexico
Summer green, winter dry

Tropical Rainforest Biome

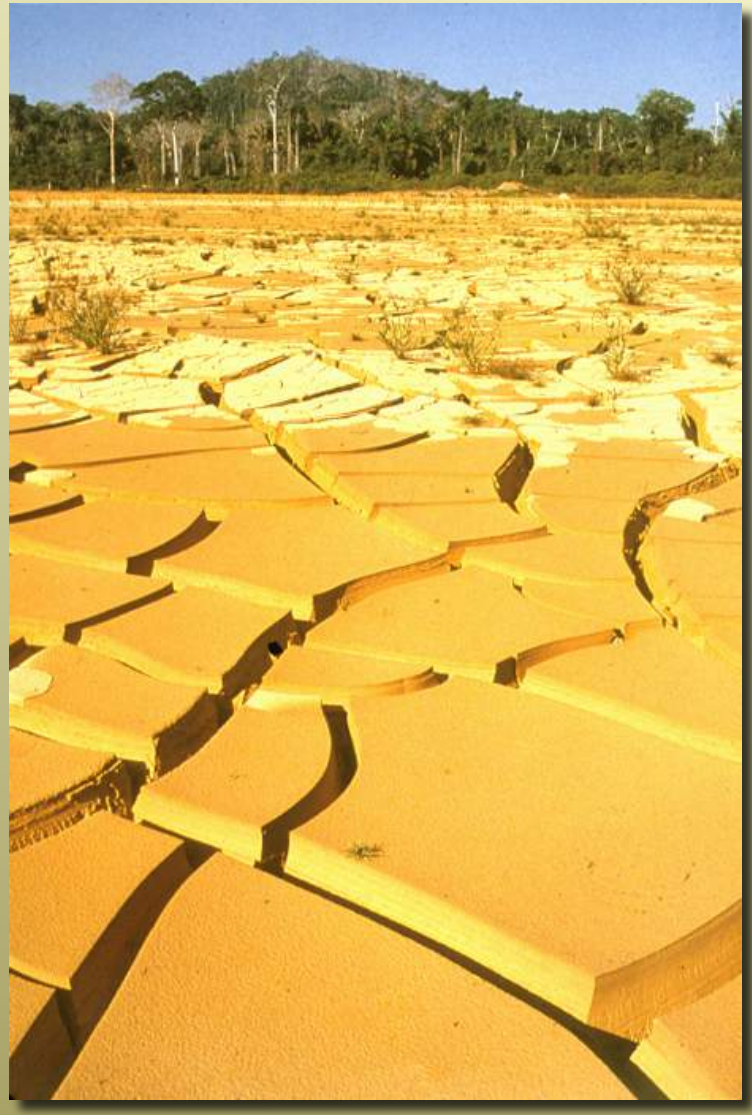
Climate

- diurnal patterns (not seasonal)
- 25° C mean annual temperature



- daily convectional precipitation
- 2 - 4 meters + rain

Tropical Rainforest Biome



Brazil - after deforestation

Soil

- warm soil and water surplus promote rock decomposition
- reddish laterite soil
- well leached, no litter

Hawaiian (5my) richer volcanic soil

Tropical Rainforest Biome

Panama slash burn agriculture

Soil

- soil incapable of holding nutrient base cations
- nutrients held in biomass
- slash-burn agriculture depletes nutrients in biomass and soil

Brazil cattle grazing following limited slash burn agriculture

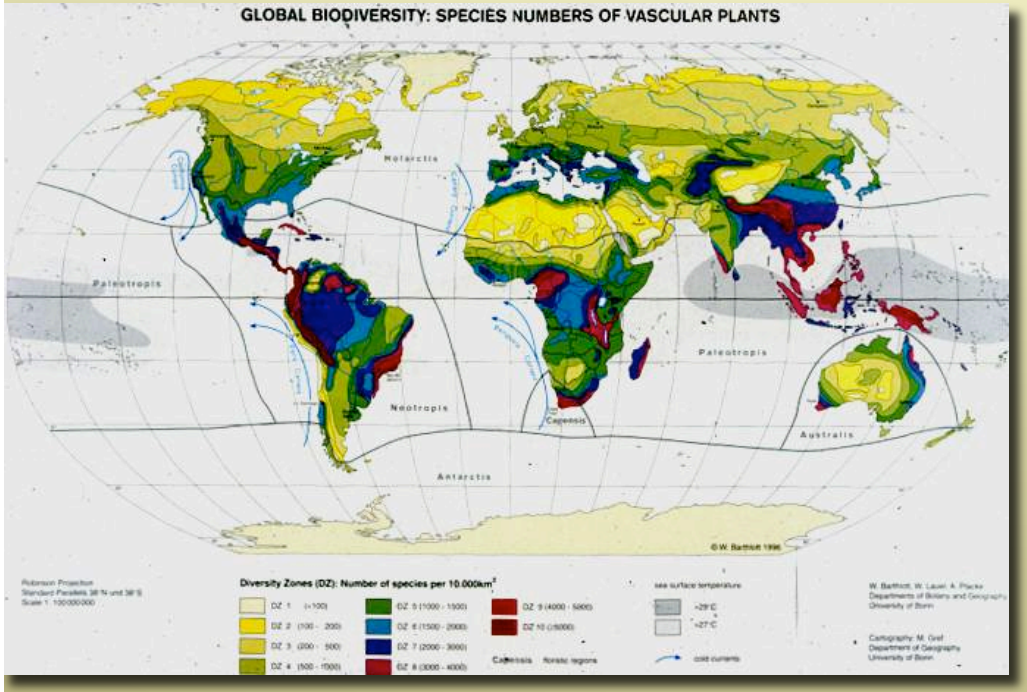
Tropical Rainforest Biome

Vegetation

- warm & wet climate allows for **broadleaf evergreen forest** to dominate
- net productivity is highest of terrestrial biomes
- highest diversity (species number) of any biome

Tropical Rainforest Biome

Diversity – 2% of earth surface, 50% of total species diversity

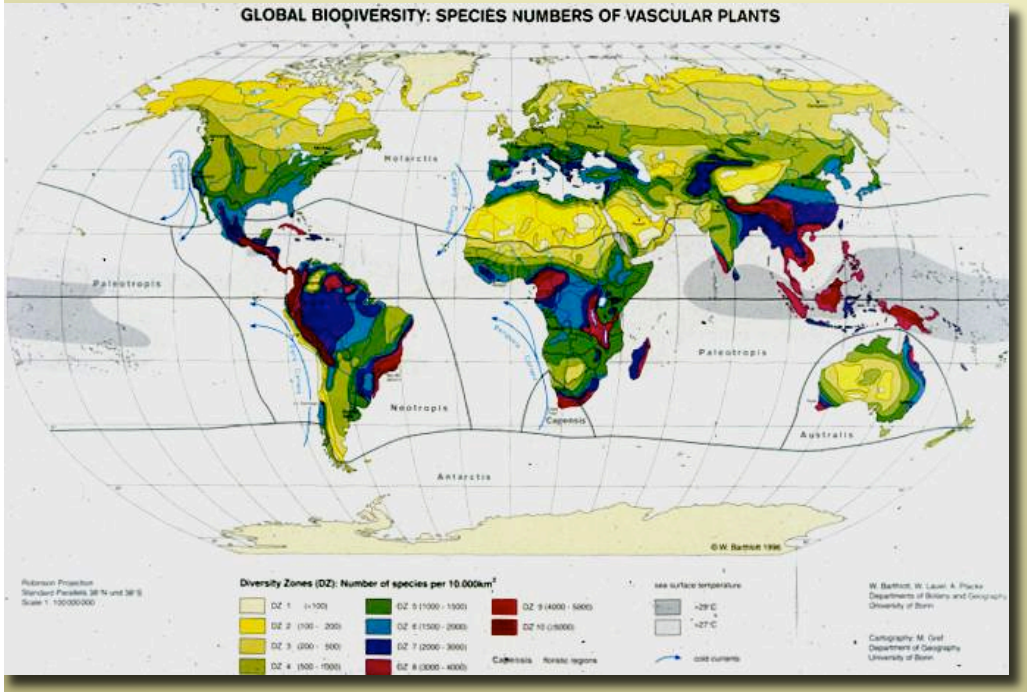


- 100,000 +/- species of flowering plants (40% of world's angiosperm flora)
- many undescribed

Al Gentry (UW grad) holds undescribed **genus** of liana

Tropical Rainforest Biome

Diversity – 2% of earth surface, 50% of total species diversity



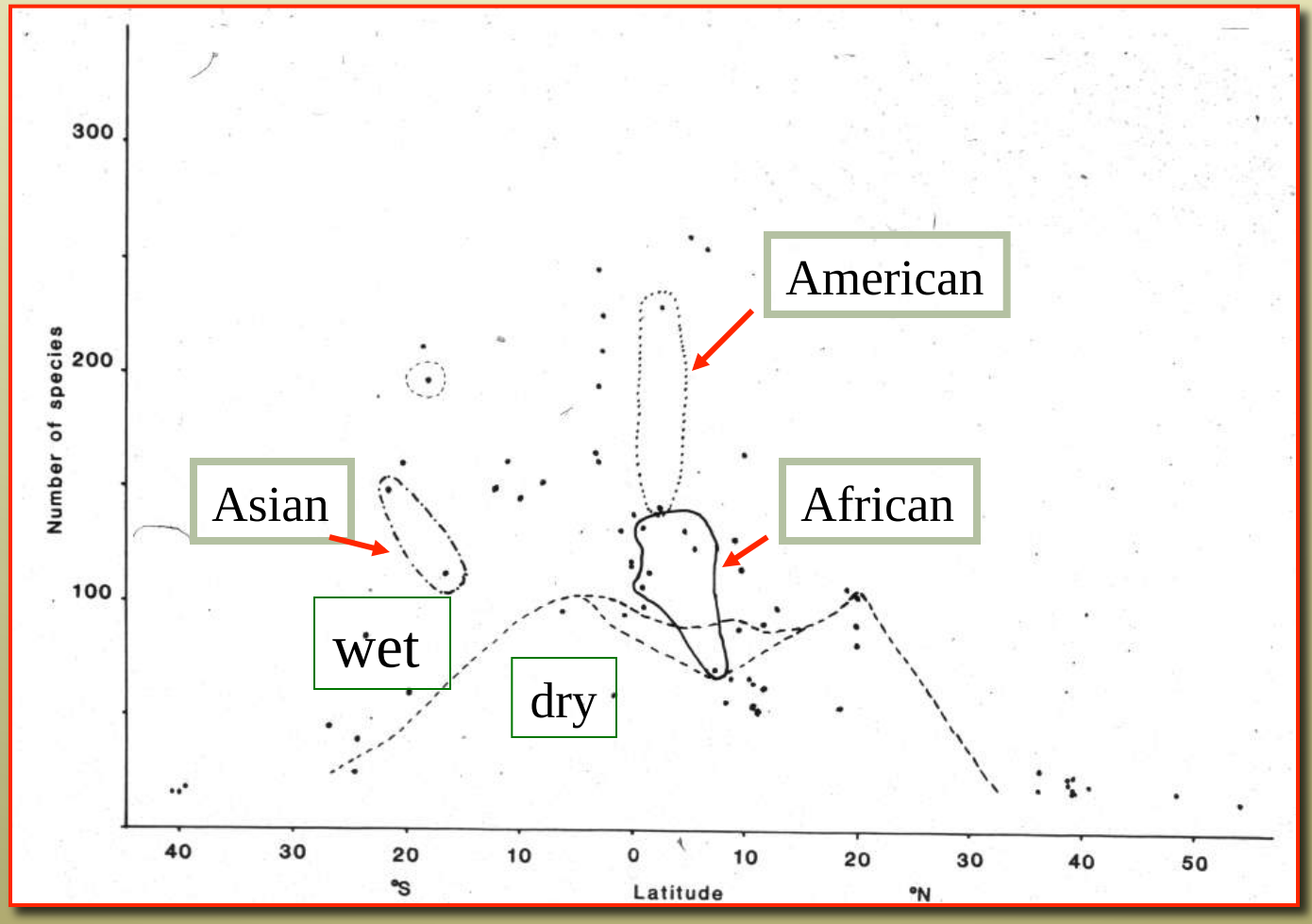
• species diversity comes from the **R**apid **A**ssessment **P**rogram of Conservation International

• two leaders were Ted Parker (ornithologist) and Al Gentry (botanist)

• knew by sight (or sound) more tropical American birds and plants, respectively, than anyone else to date

Tropical Rainforest Biome

Why this diversity? • correlation with low latitude and rainfall



Tree species diversity in 1 hectare wet and dry forests (Gentry)

Tropical Rainforest Biome

Why this diversity?

- stable ecologically?
- climatic change, allopatric speciation?
- coevolution with animals?

Virola (nutmeg family)
Bird dispersed fruits

Tropical Rainforest Biome

Where is the diversity?

- in the tree strata primarily
- 40 - 100 woody species per hectare

Amazon	*Wisconsin*
60,000 spp.	2,500 spp.
6,000 trees	50 trees

Tropical Rainforest Biome

Floristic dissimilarity of 3 regions

- palms (Arecaceae) basically lacking in Africa (but not Madagascar) and diverse in Malaysia and South America

Madagascar

Malaysia

Tropical Rainforest Biome

Floristic dissimilarity of 3 regions

- dipterocarps (Dipterocarpaceae) in SE Asia, lacking elsewhere

Does it suggest only ancient floristic linkage of tropical biomes?

Dipterocarp forest in Borneo

Tropical Rainforest Biome

Floristic nature of 3 regions

Similar families of trees involved in each floristic region, but quite different genera and species

Gentry tropical forest study sites

Table 2.2 Characteristic families and genera containing dominant, abundant, conspicuous or subendemic woody plants in the rain forests of the world, with associated epiphytes and secondary forest trees (after Longman and Jeník, 1987; Mabberley, 1992)

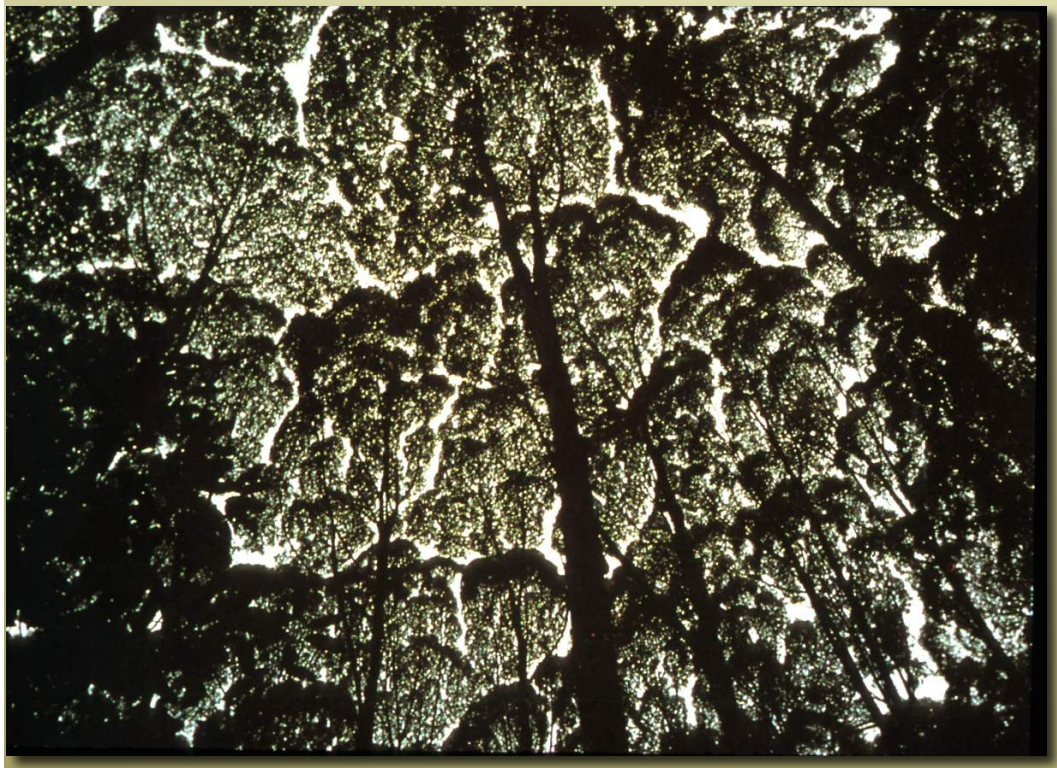
Neotropics	
Leguminosae	*Andira, Apuleia, Dalbergia, Dinizia, Hymenolobium, Mora*
Sapotaceae	*Manilkara, Pradosia*
Meliaceae	*Cedrela, Swietenia*
Euphorbiaceae	*Hevea*
Myristicaceae	*Virola*
Moraceae	*Cecropia, Ficus*
Lecythidaceae	*Bertholletia*
Epiphytes	ferns, Orchidaceae, Bromeliaceae, Cactaceae
Secondary	*Cecropia, Miconia, Vismia*
Africa	
Leguminosae	*Albizia, Brachystegia, Cynometra, Gilbertiodendron*
Sapotaceae	*Afrosersalisia, Chrysophyllum*
Meliaceae	*Entandrophragma, Khaya*
Euphorbiaceae	*Macaranga, Uapaca*
Moraceae	*Chlorophora, Ficus, Musanga*
Sterculiaceae	*Cola, Triplochiton*
Ulmaceae	*Celtis*
Epiphytes	ferns, Orchidaceae
Secondary	*Harungana, Macaranga, Musanga*
Indo-Malesia	
Dipterocarpaceae	*Dryobalanops, Hopea, Shorea*
Leguminosae	*Koompassia*
Meliaceae	*Aglaia, Dysoxylum*
Moraceae	*Artocarpus, Ficus*
Anacardiaceae	*Mangifera*
Dilleniaceae	*Dillenia*
Thymelaeaceae	*Gonystylus*
Epiphytes	ferns, Orchidaceae, Asclepiadaceae, Rubiaceae
Secondary	*Glochidion, Macaranga, Mallotus, Melastoma*

(Source: K. A. Longman and J. Jeník, *Tropical Forest and its Environment*, 2nd edn; published by Longman, 1987.)

Tropical Rainforest Biome

Structure of the vegetation: **Trees**

- tall trees form continuous canopy; therefore dense shade below
- pervasive problem of extreme light at canopy vs. low light *quantity* within forest



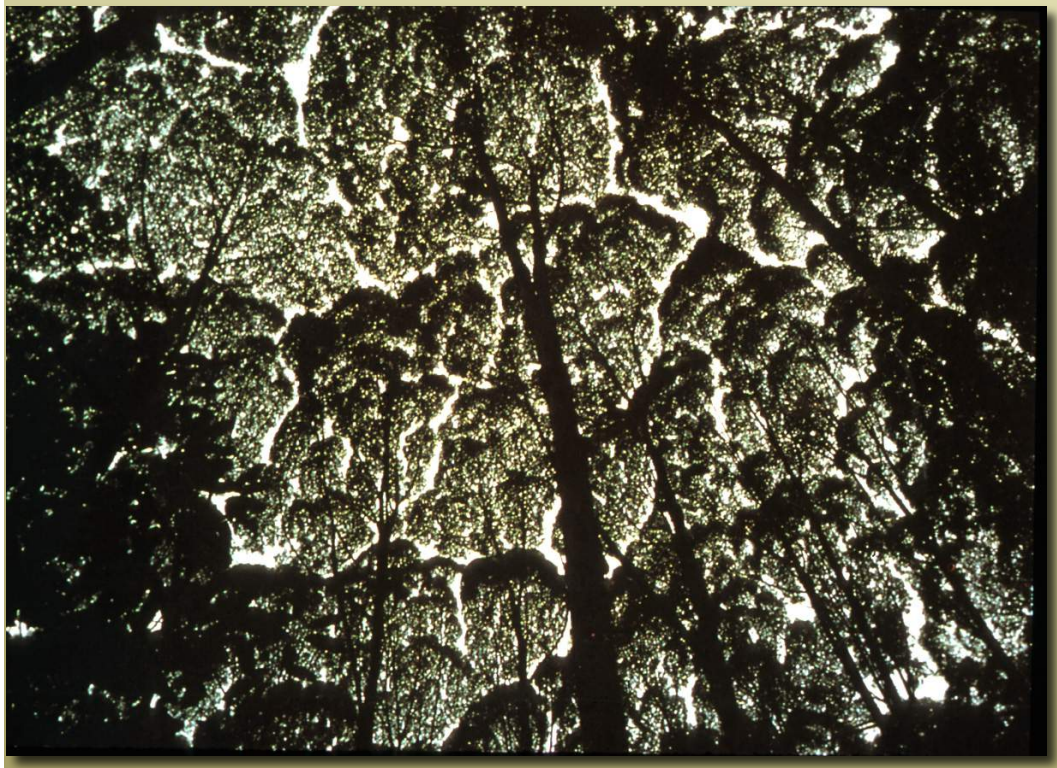
Dense canopy in Borneo

Dense canopy in Costa Rica

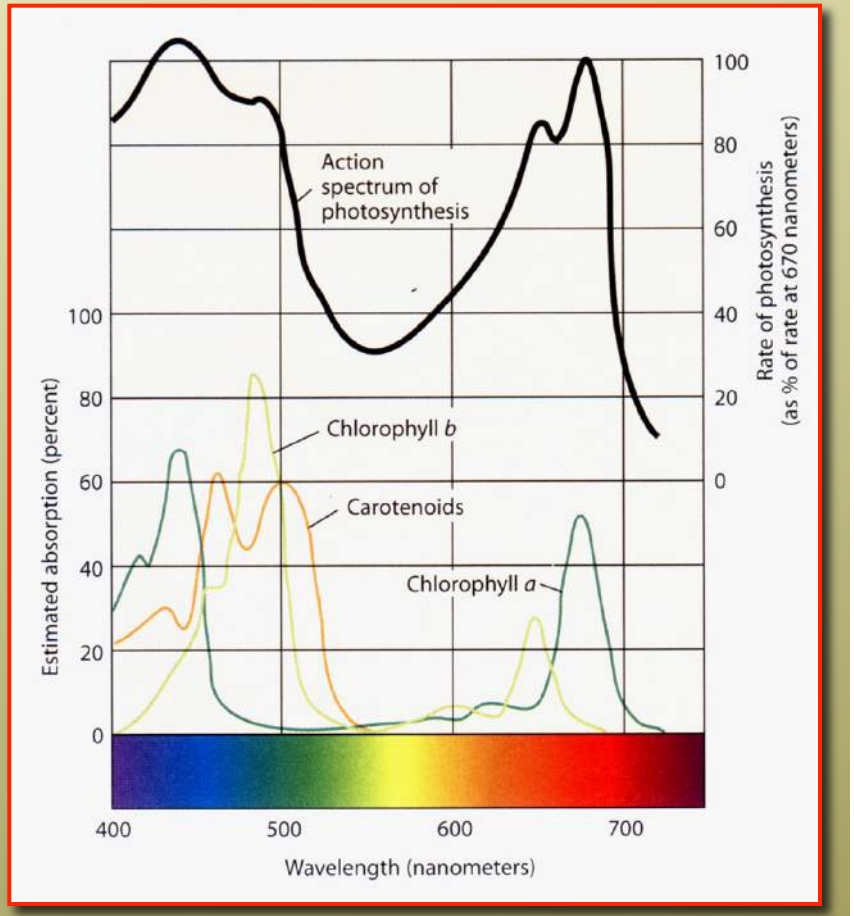
Tropical Rainforest Biome

Structure of the vegetation: **Trees**

. . . and low light *quality* within forest



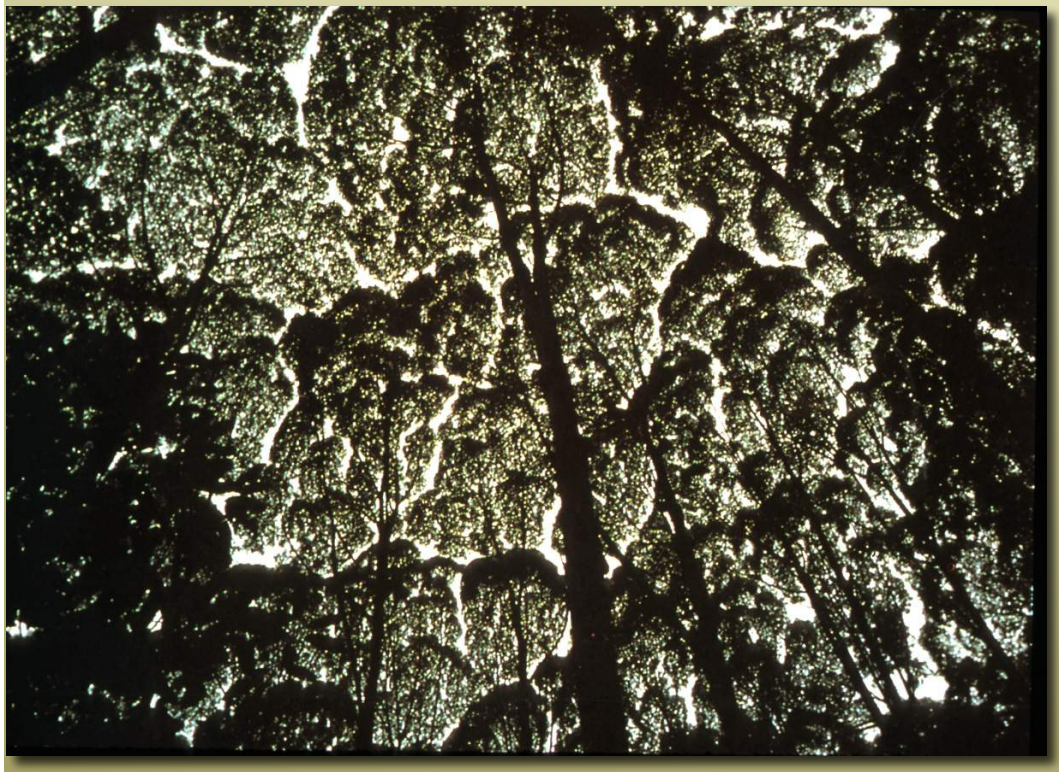
Dense canopy in Borneo



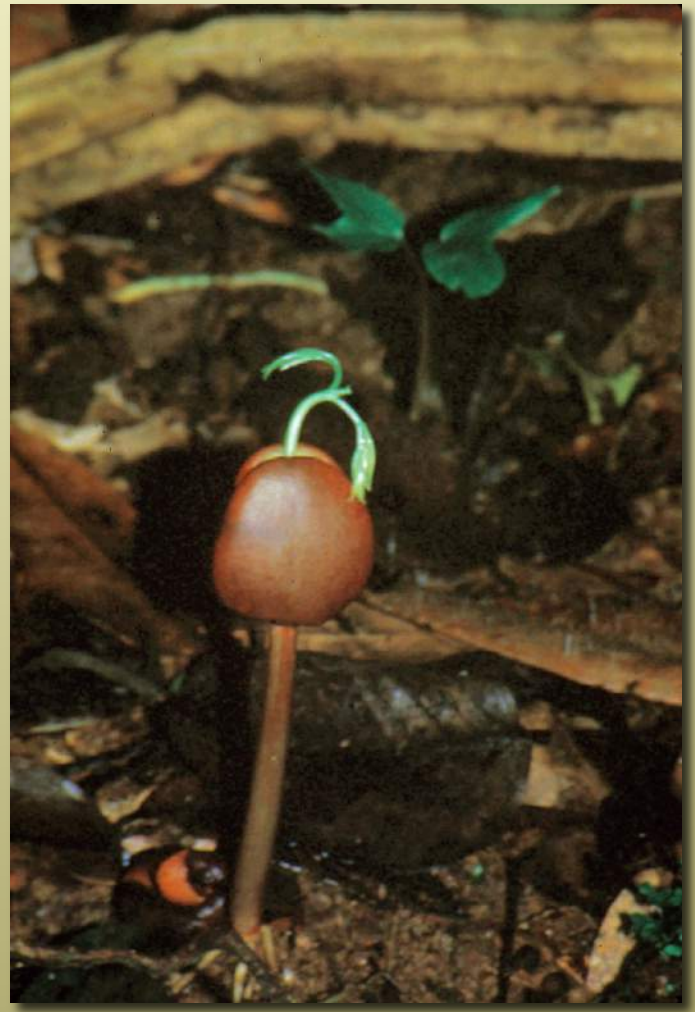
Tropical Rainforest Biome

Structure of the vegetation: **Trees**

• struggle for light has generated similar life forms and physiological adaptations in unrelated species



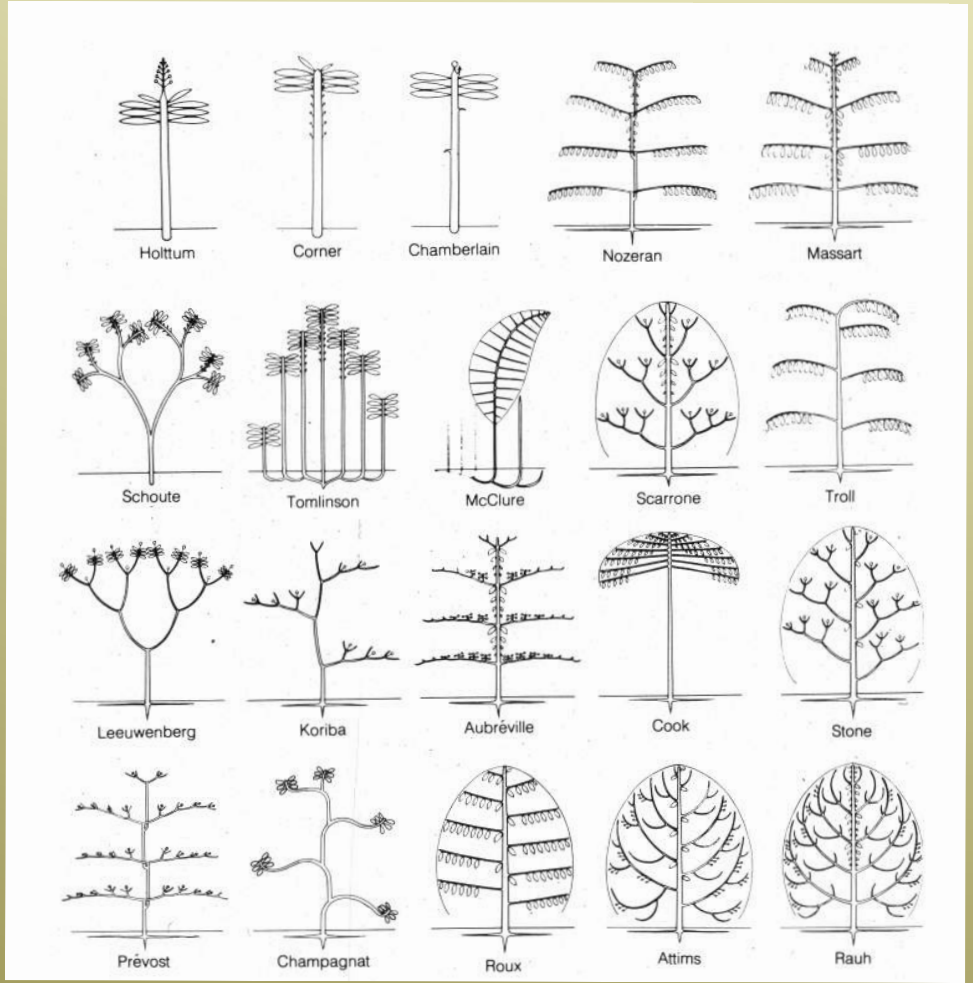
Dense canopy in Borneo

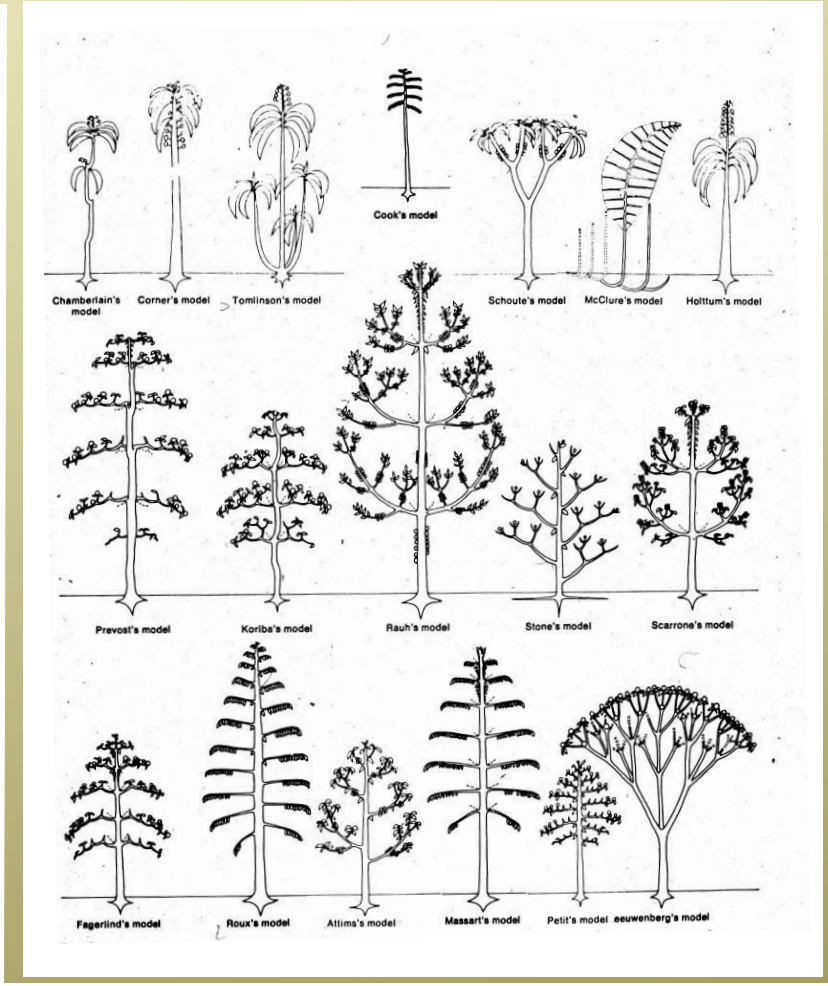


Tropical Rainforest Biome

Structure of the vegetation: **Trees**

• tropical trees show characteristic shape and branching (convergence)





Tropical Rainforest Biome

Structure of the vegetation: **Trees - 3 strata**

- emergent crowns discontinuous; 40 m (130 ft) tall

American tropics

Asian tropics

Tropical Rainforest Biome

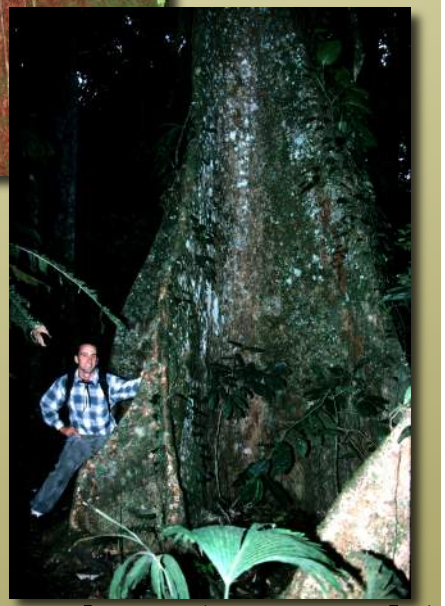
Structure of the vegetation: **Trees - 3 strata**

• buttress or plank roots for shallowly rooted trees - convergent evolution

Swietenia - mahogany (Costa Rica)

Stockwellia (Australia)

dipterocarp (Borneo)



Gyranthera (Venezuela)

Tropical Rainforest Biome

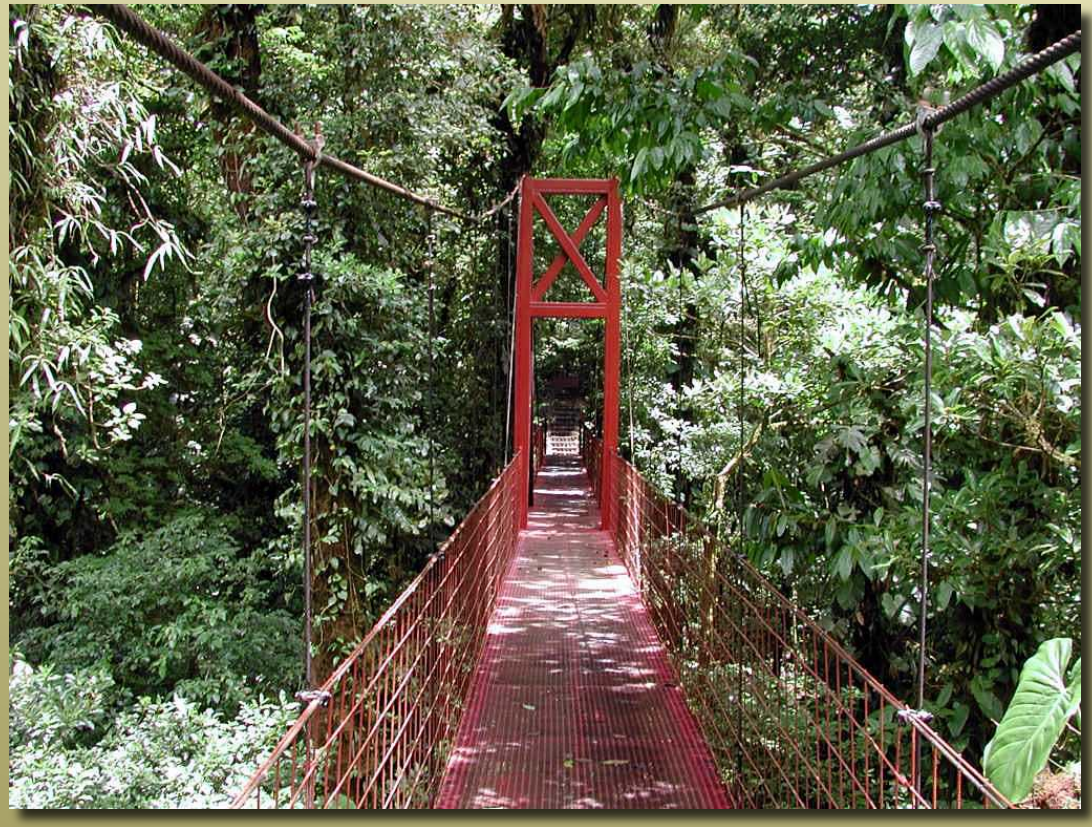
Structure of the vegetation: **Trees - 3 strata**

- continuous canopy at 15-30 m (50-100 ft)

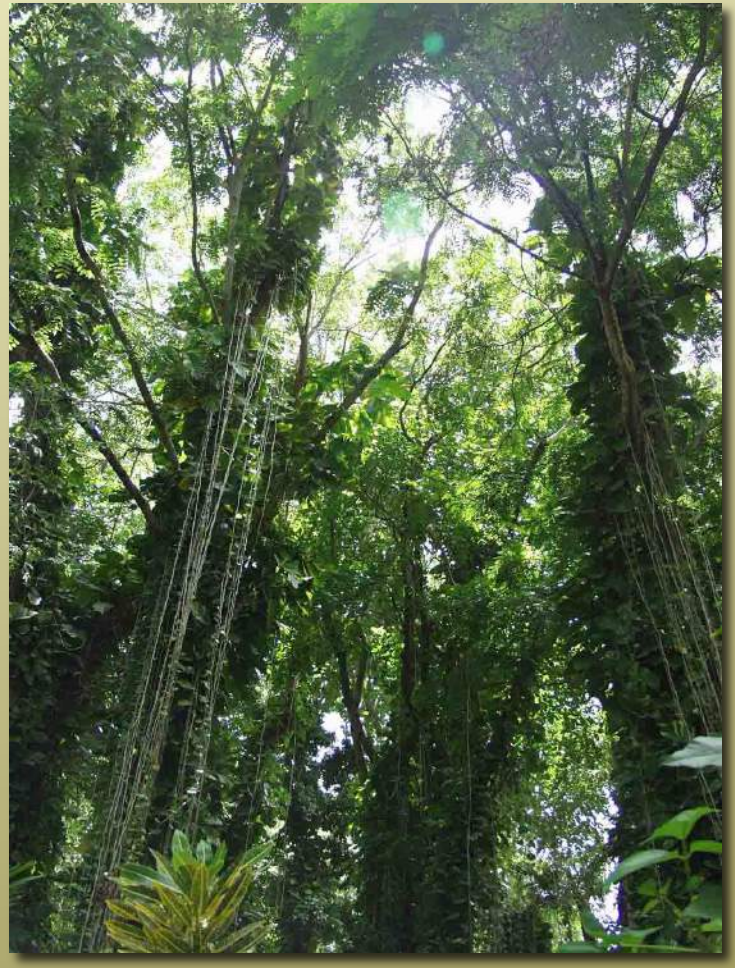
Tropical Rainforest Biome

Structure of the vegetation: **Trees - 3 strata**

- continuous canopy at 15-30 m (50-100 ft)



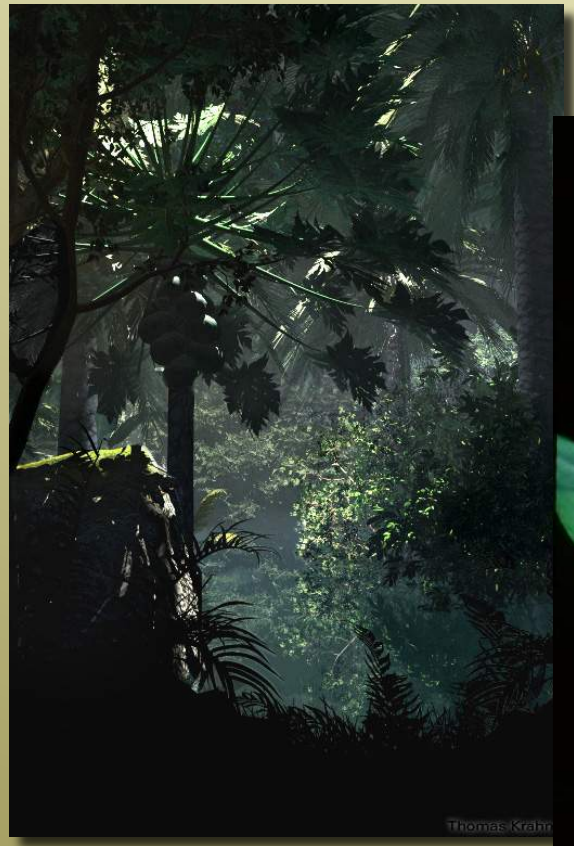
Canopy walk in Costa Rica



Tropical Rainforest Biome

Structure of the vegetation: **Trees - 3 strata**

• lower zone at 5-15 m (15-50 ft); palms and palm relatives often dominate here



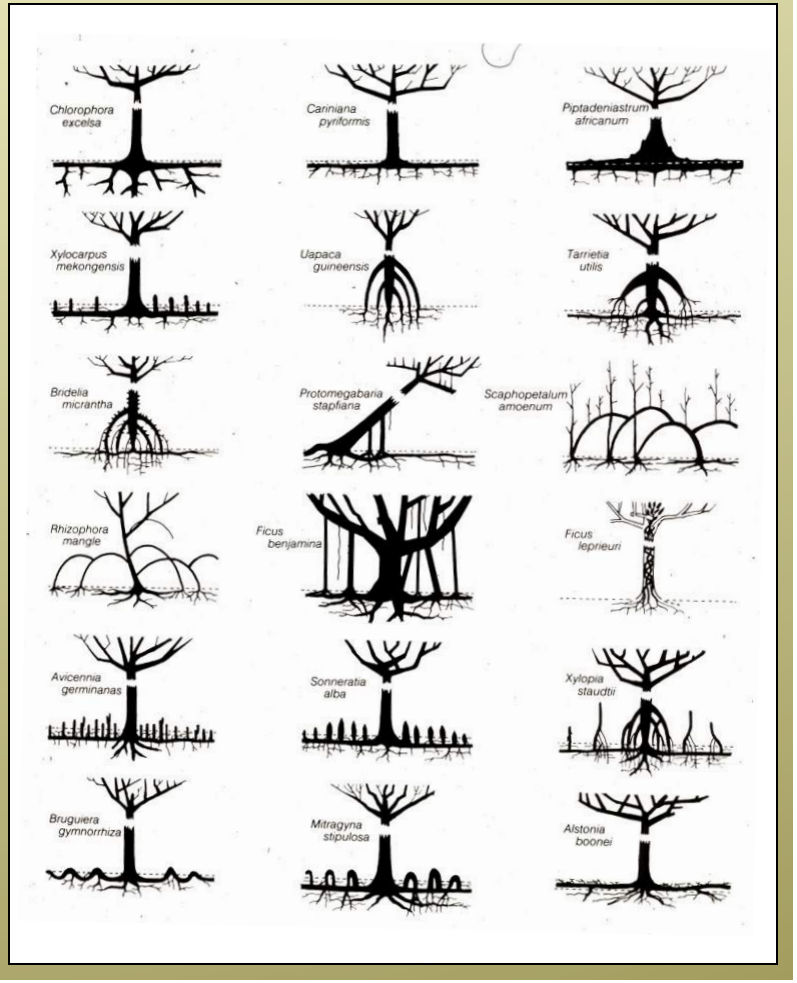
Tropical Rainforest Biome

Structure of the vegetation: **Trees - 3 strata**

• lower zone at 5-15 m (15-50 ft); small, slender crowns, stilt roots for support - convergent

Palm - Panama

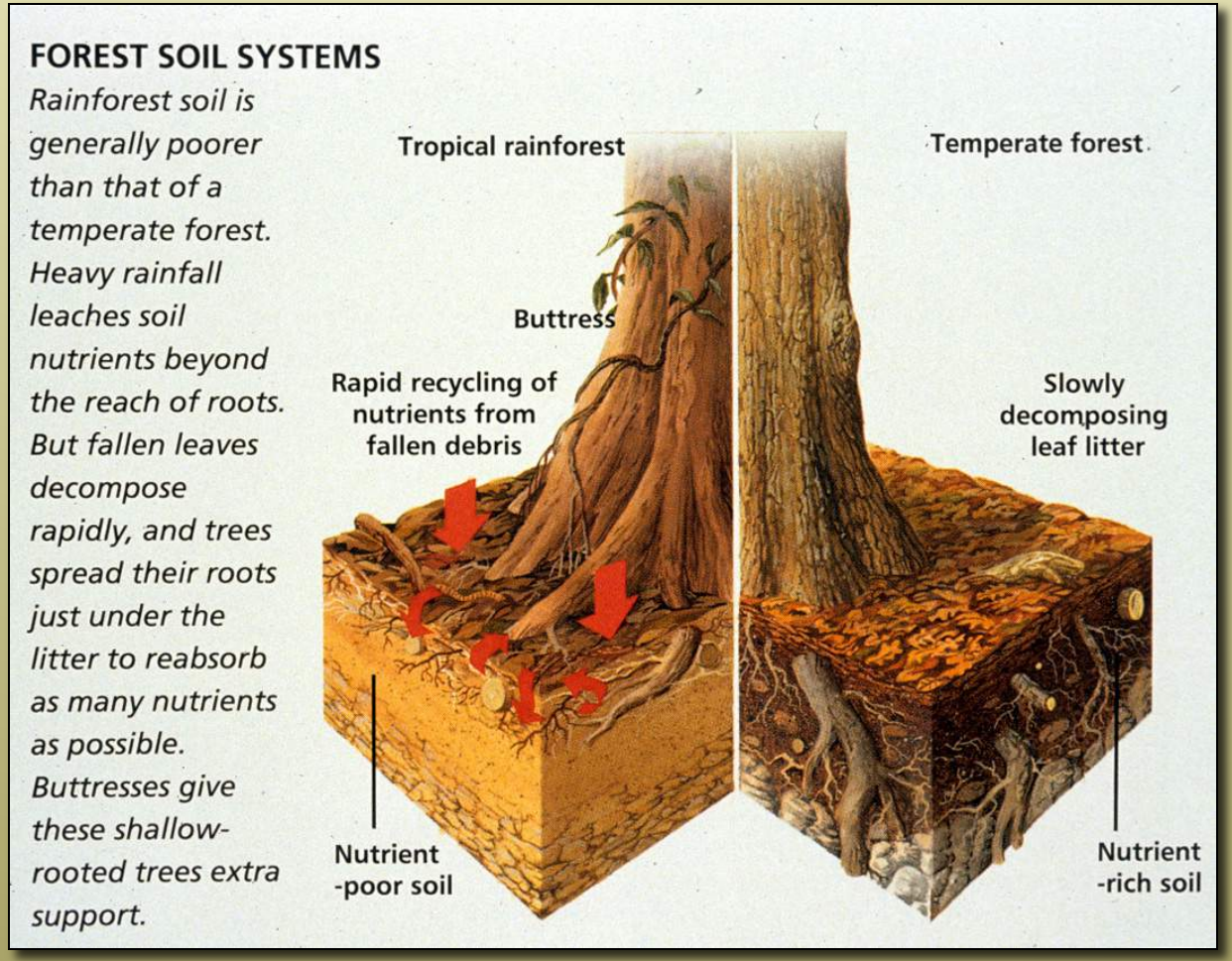
Hornstedtia
(Zingiberaceae)
Borneo



Tropical Rainforest Biome

Structure of the vegetation: **Tree roots**

- shallow feeder roots efficient in taking up nutrients
- often mycorrhizal



Tropical Rainforest Biome

Structure of the vegetation: **Tree roots**

- shallow feeder roots efficient in taking up nutrients
- often mycorrhizal
- fungi/bacteria recycle nutrients quickly for roots

Tropical Rainforest Biome

Structure of the vegetation: **Leaves**

- canopy leaves exposed to recurrent dry periods - evergreen, thick cuticle, leathery

Ficus - fig (Moraceae)

Syzygium (Australia)

Tropical Rainforest Biome

Structure of the vegetation: **Leaves**

- compound leaves common

Ceiba - kapoc (Malvaceae)

- new leaves with anthocyanin flush to prevent photo-oxidation

Sterculia - (Malvaceae)

Tropical Rainforest Biome

Structure of the vegetation: **Leaves**

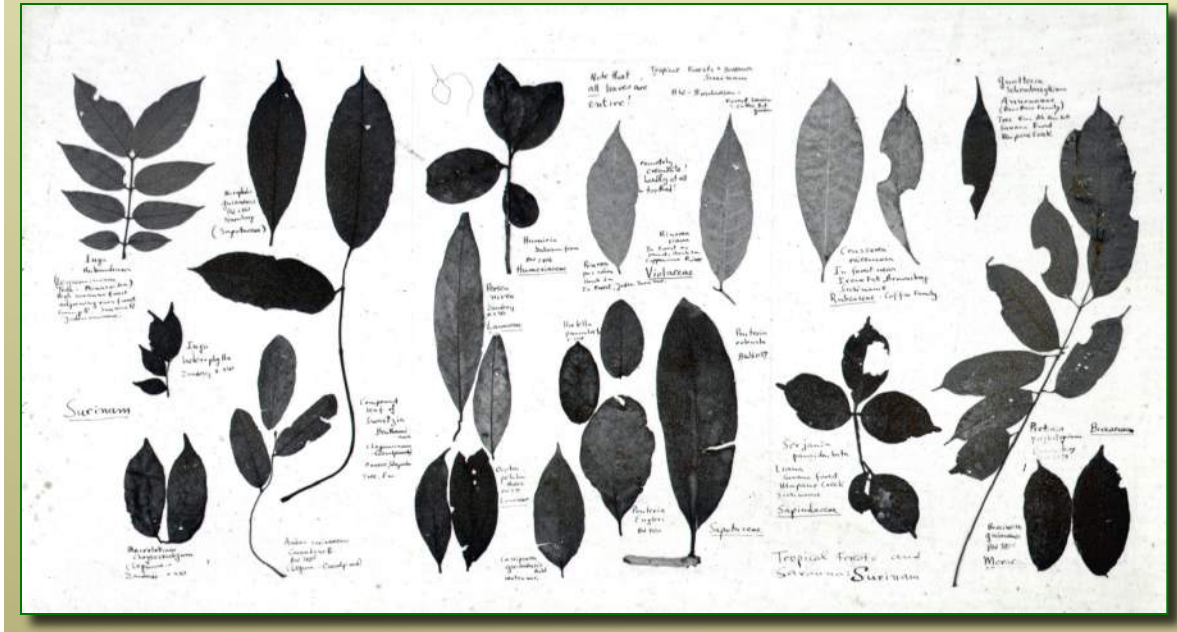
- interior forest more stable (dark and humid)
- drip tip leaves common

Ficus - fig

Tropical Rainforest Biome

Structure of the vegetation: **Leaves**

- Ghana undergrowth study with 90% drip tips



- *Nepenthes* (Asian pitcher plant) drip tip converted into carnivorous trapping structure

Tropical Rainforest Biome

Structure of the vegetation: **Herbs**

- 70-90% of species are trees
- low light levels discourage herbs
- some common families

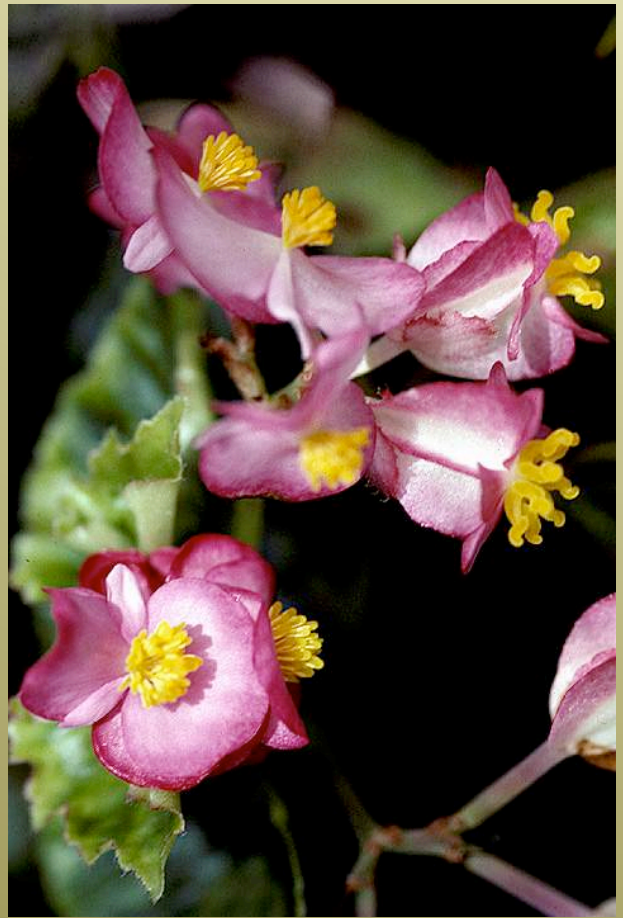
Gesneriaceae - African violet family

Melastomataceae - melastome family

Tropical Rainforest Biome

Structure of the vegetation: **Herbs**

- 70-90% of species are trees
- low light levels discourage herbs
- other common families



Begoniaceae - begonia family

Commeliniaceae - spiderwort family

Tropical Rainforest Biome

Structure of the vegetation: **Herbs**

- velvety, variegated, or metallic shimmer leaves

- adaptive in low light conditions

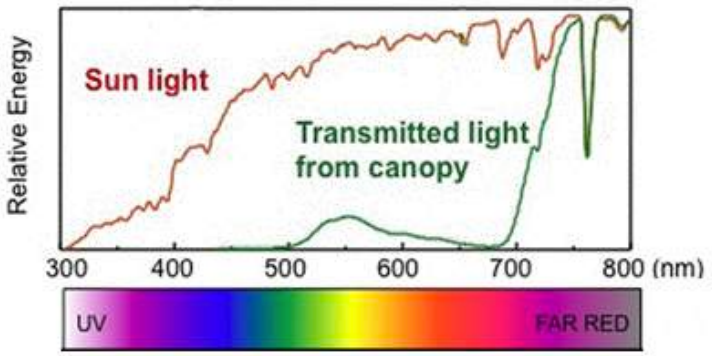


Figure 1. Comparison of full sunlight spectrum to that beneath a canopy of trees.

Tropical Rainforest Biome

Structure of the vegetation: **Herbs**

- **coarse herbs** common in riparian (river edge) or gap habitats
- order Zingiberales (banana families: heliconias, gingers, etc.)

Heliconia (Heliconiaceae)

Costus (Costaceae)

Tropical Rainforest Biome

Structure of the vegetation: **Herbs**

- **mycorrhizal parasites** common
- adaptation to low nutrients (mycorrhizal) and low light (non-photosynthetic)

Voyria (Gentianaceae)

Triuris (Triuridaceae)

Tropical Rainforest Biome

Structure of the vegetation: **Herbs**

- **parasites** common
- adaptation to low nutrients (parasitize plants) and low light (non-photosynthetic)

Rafflesia (Rafflesiaceae)

Heliosis (Balanophoraceae)

Tropical Rainforest Biome

Structure of the vegetation: **Herbs**

- **fungi** common
- non-photosynthetic

Stinkhorn

Bracket fungus

Tropical Rainforest Biome

Structure of the vegetation: **Lianas —** a cost effective method in struggle for light

• exploit tree as support for rapidly growing flexible stem and branch in canopy

Combretum (Combretaceae)

Ficus - fig (Moraceae)

Tropical Rainforest Biome

Structure of the vegetation: **Lianas —** a cost effective method in struggle for light

• 90% of all lianas confined to wet tropical rainforests - why?

• rope-like (20cm, 8in) but with pliable secondary thickenings

Ficus - fig (Moraceae)

Tropical Rainforest Biome

Structure of the vegetation: **Lianas**

- other common liana families

Bignoniaceae - catalpa family

Apocynaceae - dogbane family

Cucurbitaceae - gourd family

Gurania and other cucurbit flowers are sole source of nectar for adult heliconid butterflies

Tropical Rainforest Biome

Structure of the vegetation: **Lianas**

- other common liana families

Passifloraceae - passion flower family

Passiflora leaves are sole source of food for heliconid butterfly larvae

Tropical Rainforest Biome

Structure of the vegetation: **Epiphytes** — a cost effective method in struggle for light

- germination in top most branches of host tree
- host solely as means of physical support

Epiphytes in Costa Rica canopy walk

- flowering plants, ferns, mosses, liverworts, lichens, algae (**epiphylls**)

Tropical Rainforest Biome

Structure of the vegetation: **Epiphytes —** a cost effective method in struggle for light

- the study and collection of epiphytes one of the most challenging in science

Alec Barrow - Barro Colorado Island

Scott Mori - NY Bot Gard in Guyana

Tropical Rainforest Biome

Structure of the vegetation: **Epiphytes —** a cost effective method in struggle for light

- dominant angiosperm epiphytes:

Orchidaceae - orchids

Cactaceae - cacti

Tropical Rainforest Biome

Structure of the vegetation: **Epiphytes —** a cost effective method in struggle for light

- dominant angiosperm epiphytes:

Piperaceae - peperomias

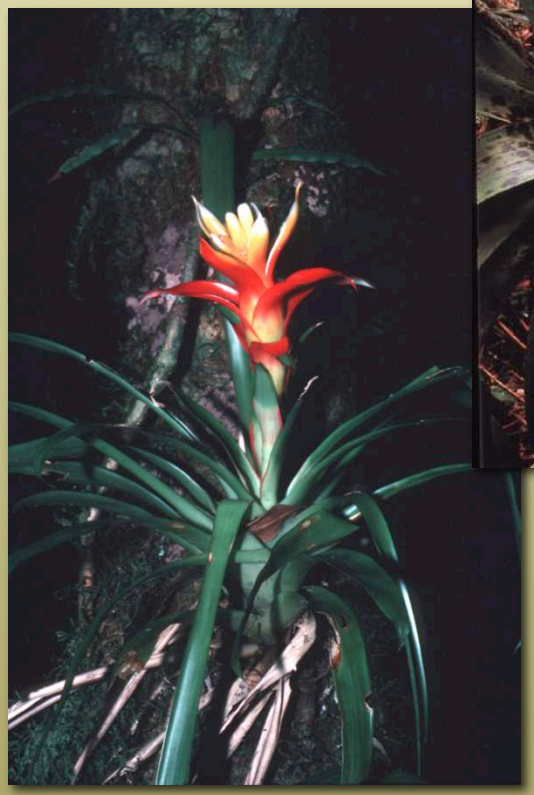
Araceae - aroids

Tropical Rainforest Biome

Structure of the vegetation: **Epiphytes —** a cost effective method in struggle for light

- dominant angiosperm epiphytes:

Gesneriaceae - African violets



Bromeliaceae - pineapples

Tropical Rainforest Biome

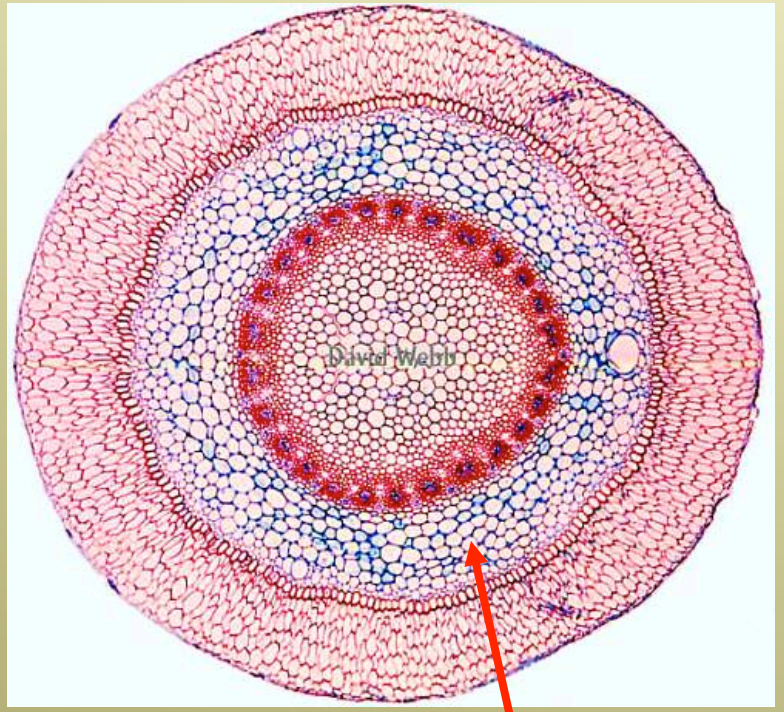
Structure of the vegetation: **Epiphytes —** adaptations to epiphytic condition — *the problem of obtaining and storing water*

water tanks (water storage)
- Bromeliaceae

Scales (water & nutrient uptake)
- Bromeliaceae

Tropical Rainforest Biome

Structure of the vegetation: **Epiphytes** — adaptations to epiphytic condition — *the problem of obtaining and storing water*



leaf tubers (water storage) - Orchidaceae

Orchid root **velamen** (water storage)

Tropical Rainforest Biome

Structure of the vegetation: **Epiphytes —** adaptations to epiphytic condition — *the problem of obtaining and storing water*

Succulence & CAM photosynthesis - Cactaceae

“trash baskets” & **aerial roots** - staghorn ferns (above) and Araceae (right)

Tropical Rainforest Biome

Structure of the vegetation: **Stranglers —** a cost effective method in struggle for light

- start as epiphytes and grow roots down host tree

Ficus (strangler fig - Moraceae)

Tropical Rainforest Biome

Structure of the vegetation: **Stranglers —** a cost effective method in struggle for light

- start as epiphytes and grow roots down host tree
- shoot elongates and roots thicken, coalesce

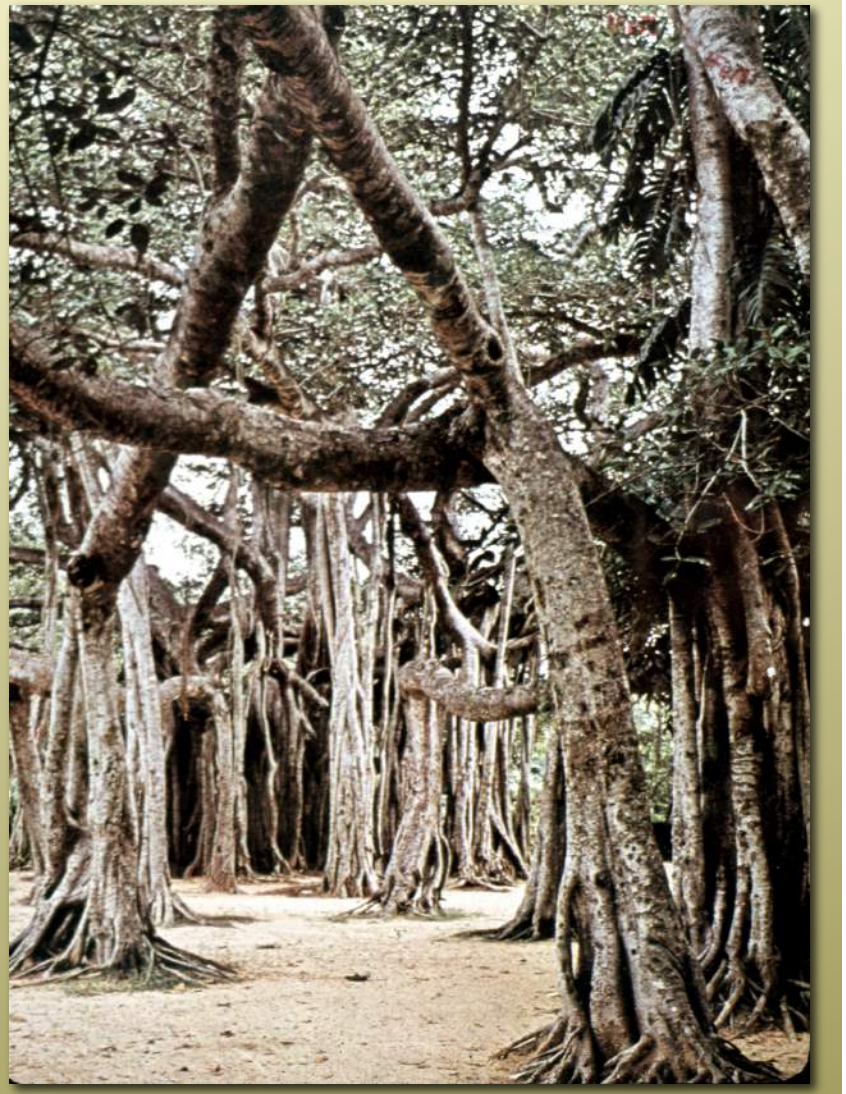
Ficus (strangler fig - Moraceae)

Tropical Rainforest Biome

Structure of the vegetation: **Stranglers —** a cost effective method in struggle for light

- strangulation of host via "root" stem

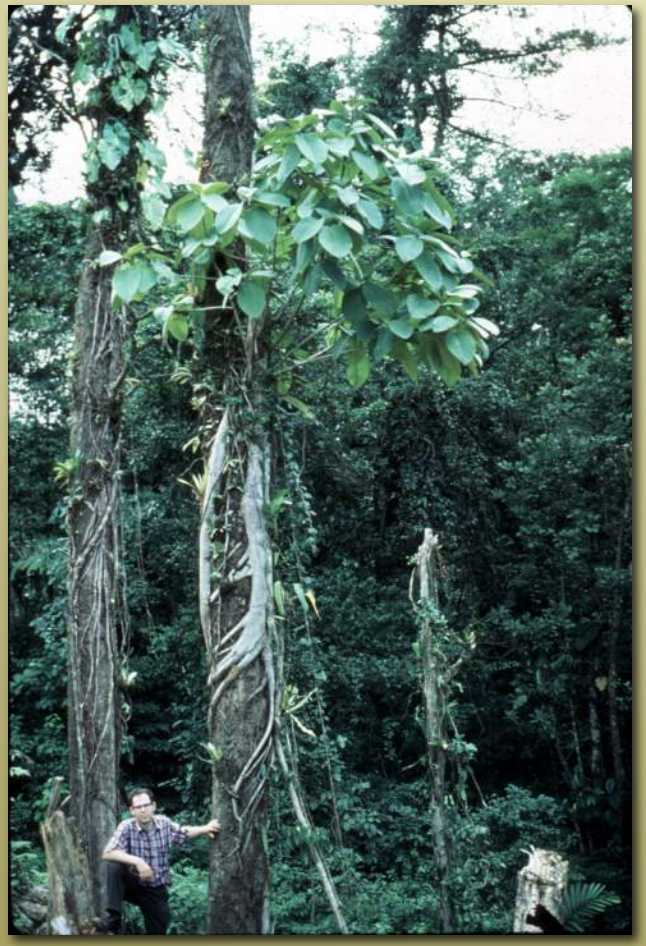
Ficus (strangler fig - Moraceae)



Tropical Rainforest Biome

Structure of the vegetation: **Stranglers —** a cost effective method in struggle for light

- other stranglers



Clusia
(Clusiaceae)

Tropical Rainforest Biome

Structure of the vegetation: **Stranglers —** a cost effective method in struggle for light

- other stranglers

Metrosideros robusta -
Northern rata (Myrtaceae)

Tropical Rainforest Biome

Structure of the vegetation: **Hemi-epiphytes**

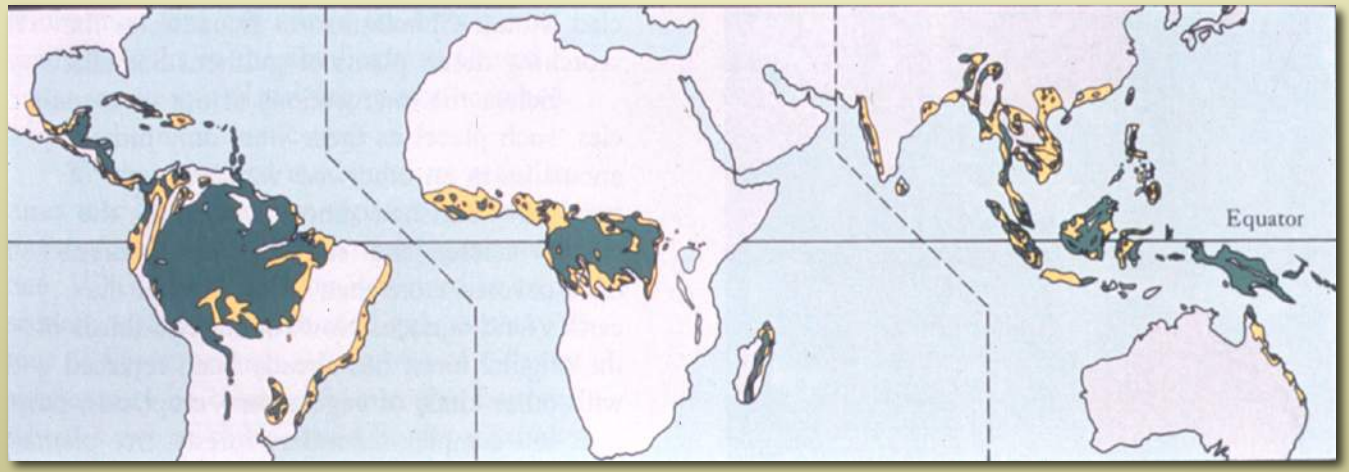
- germinate on ground, grow up as lianas (root climbers)
- bottom dies, becomes epiphytes
- “walk” through forest looking for light

Anthurium & Philodendron (aroid - Araceae)

Philodendron (aroid - Araceae)

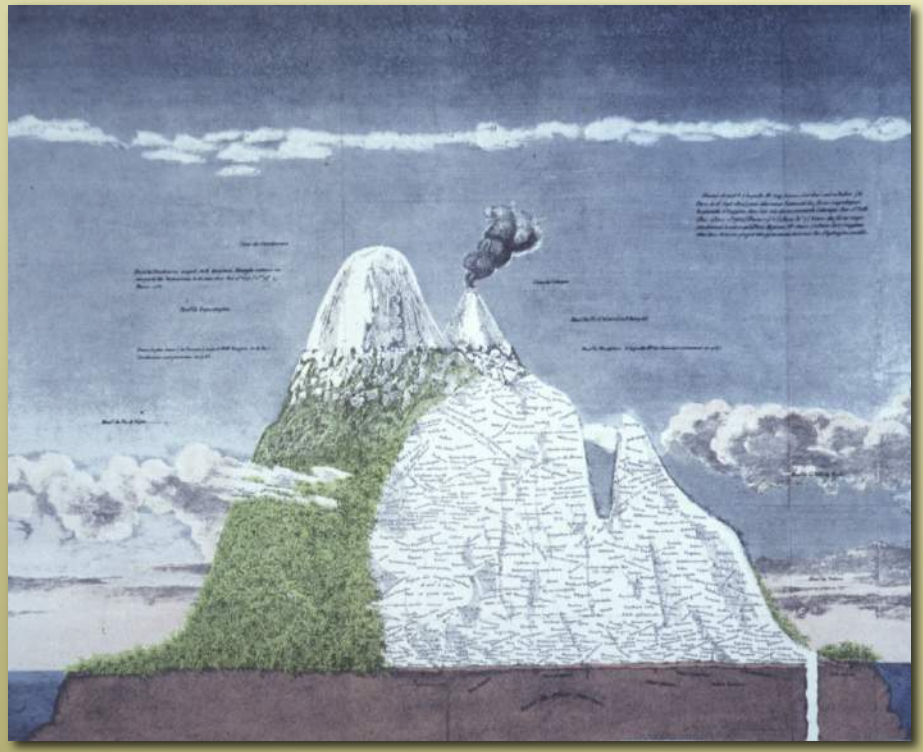
Cloud Forest or Tropical Montane Biome

- Form when moisture laden winds encounter mountains



Cloud Forest or Tropical Montane Biome

- Form when moisture laden winds encounter mountains
- Elevation and humidity related - not precise location



Andean cloud forests higher

Panamanian cloud forests lower

Cloud Forest or Tropical Montane Biome

- epiphytes most abundant here
- trees smaller, lianas rare

Cloud Forest or Tropical Montane Biome

- characteristic groups of cloud forests

- tree ferns

Cyathea

Cloud Forest or Tropical Montane Biome

- characteristic groups of cloud forests

Hymenophyllum - filmy fern

- filmy ferns (Hymenophyllaceae)
- club mosses, spike mosses, true mosses

Selaginella - spike moss

Cloud Forest or Tropical Montane Biome

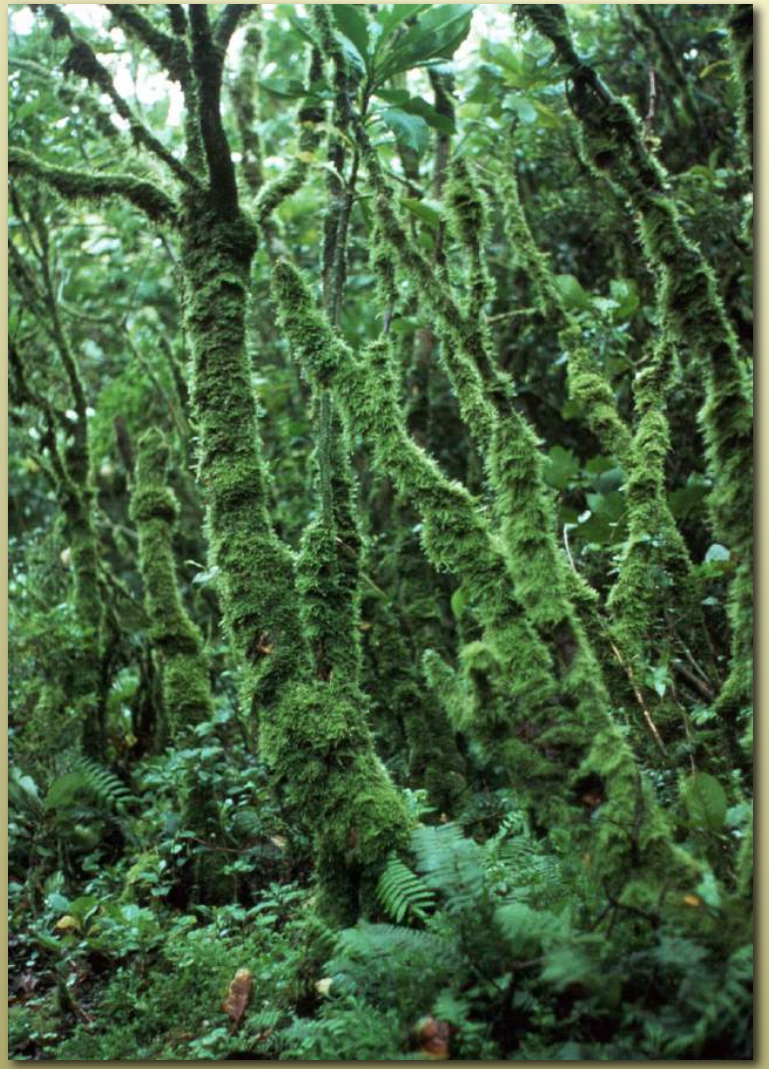
- characteristic groups of cloud forests

- *Gunnera* (Gunneraceae)

- Rubiaceae (coffee family)

- Ericaceae (blueberry family)

Above Tropical Montane Forests



Elfin forest - Costa Rica

Ruwenzoris

Costa Rica - Cerro de la Muerte

Tropical subalpine, paramo

Above Tropical Montane Forests

Sierra Nevada del Cocuy National Park, Colombia [4,638 m]

Lupinus alopecuroides growing with *Senecio niveoaureus* in a superparamo

Photo: Mauricio Diazgranados

Reproductive Strategies in Tropical Forests

Pollination biology

- outcrossing mechanisms in trees, usually animal-mediated
- e.g., dioecy - separate male and female plants

Level of dioecy

Costa Rica
- 20% tall trees
- 12% small trees

Sarawak
- 26% trees

Nigeria
- 40% trees

dioecious *Clusia*

Reproductive Strategies in Tropical Forests

Pollination biology

- wind pollination rare in mature rain forests
- common in early seral stages (light gaps, cut-over forests)

- wind pollination dropped from 38% to 8% in two years after light gap formed in Costa Rica

Wind pollinated *Cecropia*

Reproductive Strategies in Tropical Forests

Pollination biology

- animal pollination involves bats, birds, bees, moths, beetles

Carrion insect/bat pollinated
Aristolochia

Hummingbird pollinated
Fuchsia

Reproductive Strategies in Tropical Forests

Pollination biology

- animal pollination involves bats, birds, bees, moths, beetles

many bat-pollinated trees are cauliflorous - flowers on stem

or with pendant flowers (*Parkia* - Fabaceae)

Reproductive Strategies in Tropical Forests

Seed or fruit dispersal

- fleshy fruits dominate (90% +)
- wind dispersal (5-10%)
- water dispersal (1-2%)

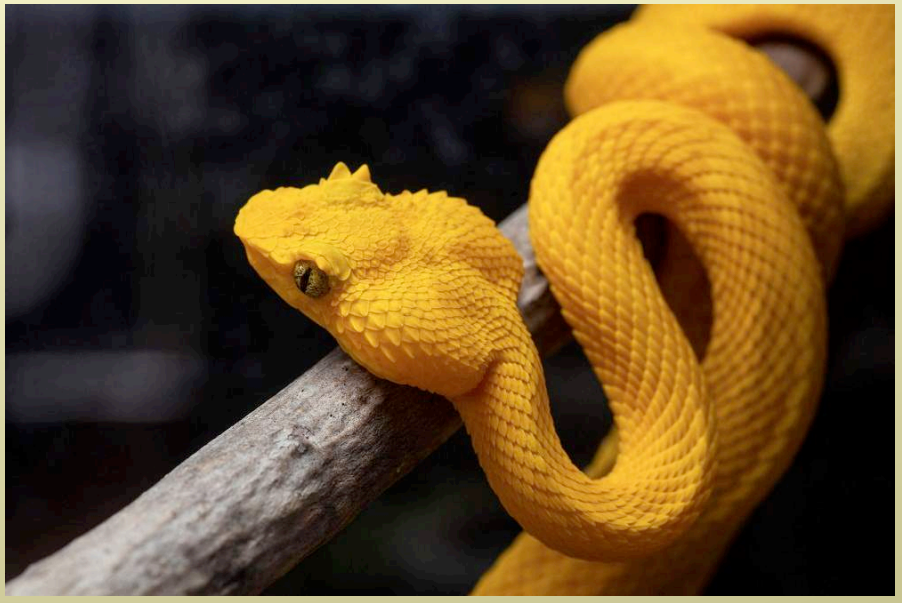
frugivorous birds

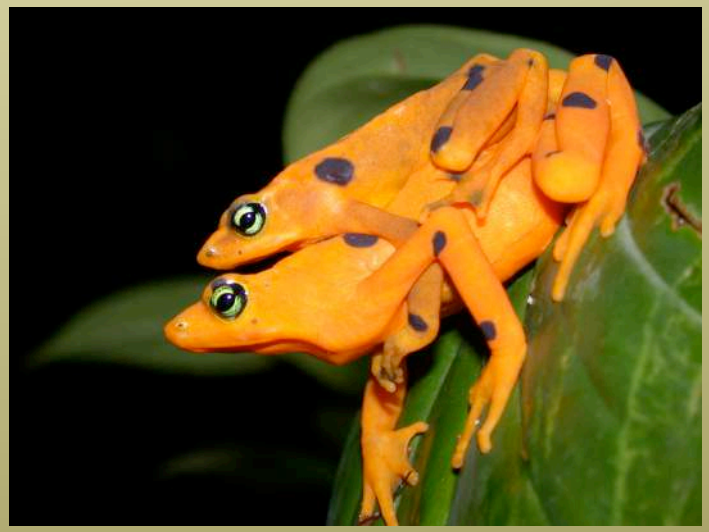
bat-dispersed figs

primate dispersed durian

Major Animal Radiations in Tropical Forests

Major Animal Radiations in Tropical Forests





Major Animal Radiations in Tropical Forests

Major Animal Radiations in Tropical Forests